2024

Eighteenth Annual

Undergraduate Summer Research Program

Abstracts



2024

A Message from the Vice Dean

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 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 crucial to this program's success. 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 of our guest speakers who provided our students with essential information and resources to ensure their future success. Detailed information about these events and presenters is included later in the booklet.

Financial support from NYU Tandon, faculty research grants, and external donors is essential for the program's continuity. This year marks the 13th anniversary of the Thompson Bartlett (TB) Fellowship, which graciously supports ten female researchers, 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 and then later taught at Tandon. Mrs. Bartlett herself is an NYU alum as well. 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 (AHA), featuring new and exciting projects from NYU Langone faculty. Generous financial contributions enable us to engage more student researchers and faculty mentors, further enriching this unique summer experience.

This past 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 successfully reintroduced in-person events for the first time since Summer 2020 and COVID-19 disruptions. 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.

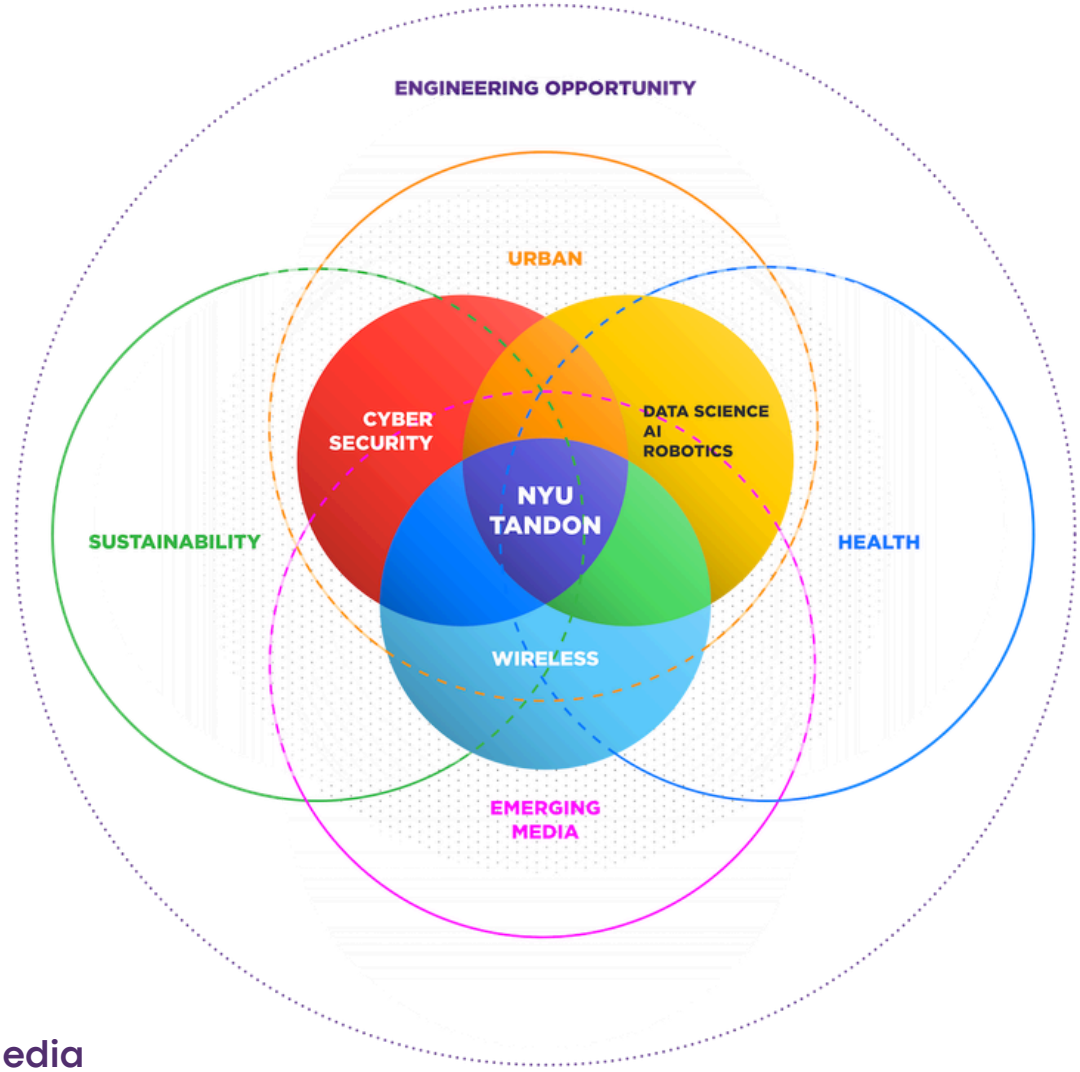


Peter Voltz
Vice Dean for Academics

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. Julia Sy worked under Sara to compile this year's Abstract Booklet. Jen Piro, Director of Undergraduate Programs, joined the coordination efforts in 2019, managing the ever important student to supervisor matching and final project placements. Kat Arrendondo, Tandon's Manager of Undergraduate Programs, joined in on the program in 2022, spearheading the event calendar and creating new engagement opportunities. Mohamed Asran also provided valuable administrative support. A huge thank you to the entire team! Congratulations to all the student researchers who participated in the 2024 UGSRP. Thank you to the Research Mentors & Staff, Dede Bartlett, Matt Frenkel, our coordinators, and additional guest speakers. Thank you also to Elena Olivo who photographed the student participants and in lab experiences featured in the booklet. I am extremely proud of this program and look forward to many more summers of intellectual and scholarly growth!

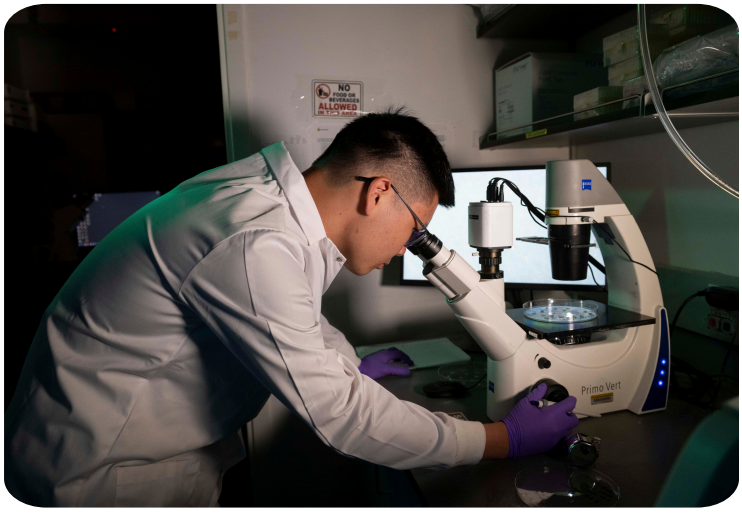
Areas of Excellence

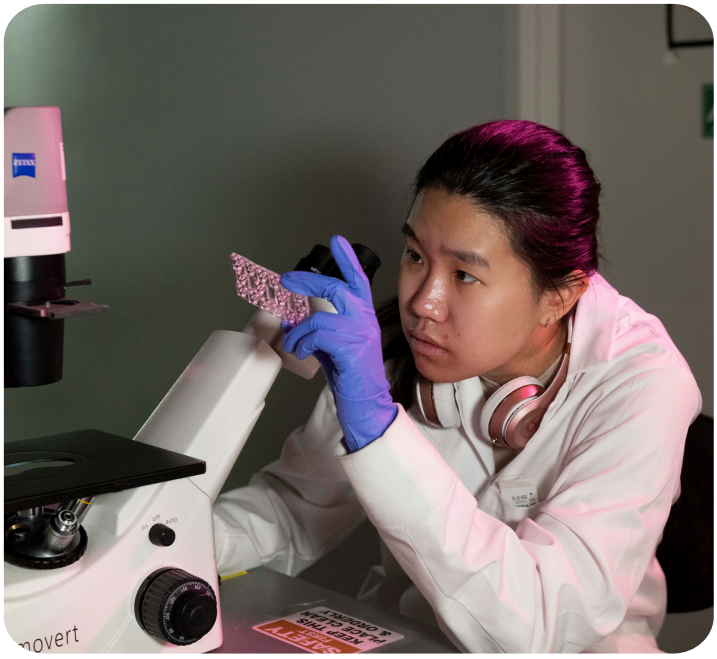
Here at Tandon, our researchers and students work at the bleeding edge of technology — technology that powers cities, enables worldwide communication, fights climate change, and creates new and safer digital worlds. We're building new devices that will revolutionize healthcare, algorithms to help us 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
- → Urban
- → Health
- → Emerging Media
- → Sustainability
- → Cybersecurity
- → Data Science/AI/Robotics

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Ndioro Ba
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Jing Jiang
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Project Supervisors & Research Staff

Project Supervisors

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Research Staff and Additional Mentors

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Calendar of Events

JUNE 3	PROGRAM ORIENTATION Jen Piro & Kat Arrendondo
JUNE 4	MICROAGGRESSIONS MODULE Recorded Webinar
JUNE 5	WHAT IS RESEARCH? Matthew Frenkel
JUNE 6-7	HEADSHOTS
JUNE 12	DEVELOPING A LITERATURE REVIEW & RESEARCH DATA FINDINGS Matthew Frenkel and Fabiha Khalid
JUNE 13	UGSRP LUNCH MIXER
JUNE 18	S2S: ETHICS IN RESEARCH Matthew Frenkel
JUNE 20	STEM GLOBAL AWARDS 1 SESSION Tara Wheelwright
JUNE 5	PROGRAM ORIENTATION Jen Piro & Kat Arrendondo
JUNE 26	S2S: PROJECT MANAGEMENT WORKSHOP Sam Putnam
JUNE 27	NSF GRFP SESSION Jamie Lloyd
JUNE 29-30	LUNA PARK Debra Laefer
JULY 1-2	LAB SHOTS
JULY 3	S2S: DEVELOPING A RESEARCH PROPOSAL Amanda He
JULY	S2S: WRITING A RESEARCH STATEMENT/ ABSTRACT Matthew Frenkel
JULY 11	UGSRP VIDEO PRESENTATION SESSION Kat Arrendondo
JULY 14	MID-PROGRAM EVALUATIONS
JULY 17	S2S: WRITING FOR PUBLICATION Matthew Frenkel
JULY 18	DIY WORKSHOP
JULY 20	UGSRP SOCIAL EVENT
JULY 21	ABSTRACTS DUE
JULY 24	S2S: CONSTRUCTING AND PRESENTING A RESEARCH POSTER Matthew Frenkle
JULY 25	PORTFOLIO DEVELOPMENT WORKSHOP Molly Ritmiller
JULY 28	ADDITIONAL PHOTOS DUE
JULY 29	VIDEO PRESENTATION ASSIGNMENT SUBMISSION DUE
JULY 30-31	RESEARCH POSTER CRITIQUE SESSION
AUGUST 4	FINAL POSTER DUE
AUGUST 7	CULMINATING EVENT AND RECEPTION/POSTER SESSION EVENT
AUGUST 9	GOOGLE PHOTOS + COMMENTS AND SUBMISSIONS
AUGUST 11	POST-PROGRAM SURVEY DUE
AUGUST 14	ABSTRACT BOOKLET ROUND 1 EDITS DUE
AUGUST 28	ABSTRACT BOOKLET ROUND 2 EDITS DUE
AUGUST 30	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 (TB)

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. Celebrating over a decade of impact, the TB Fellowship has supported over 0 fellows.

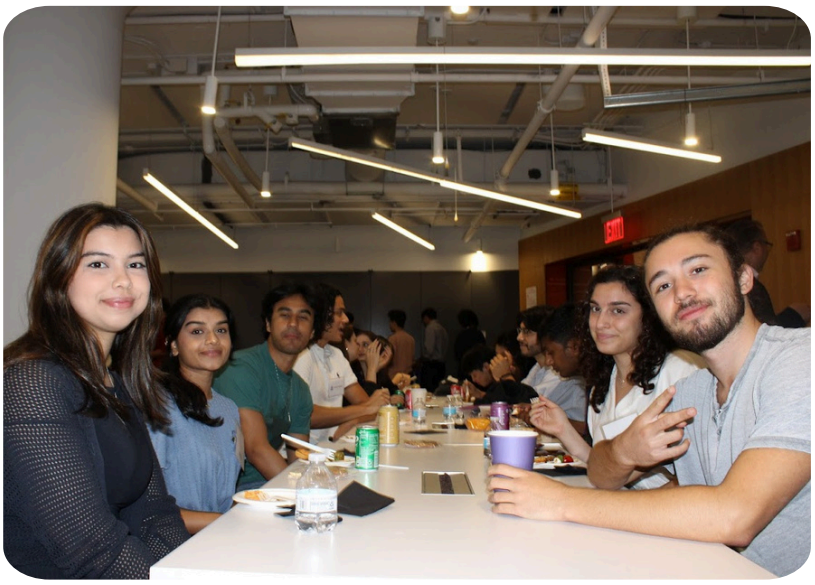
Visiting Student Fellowship

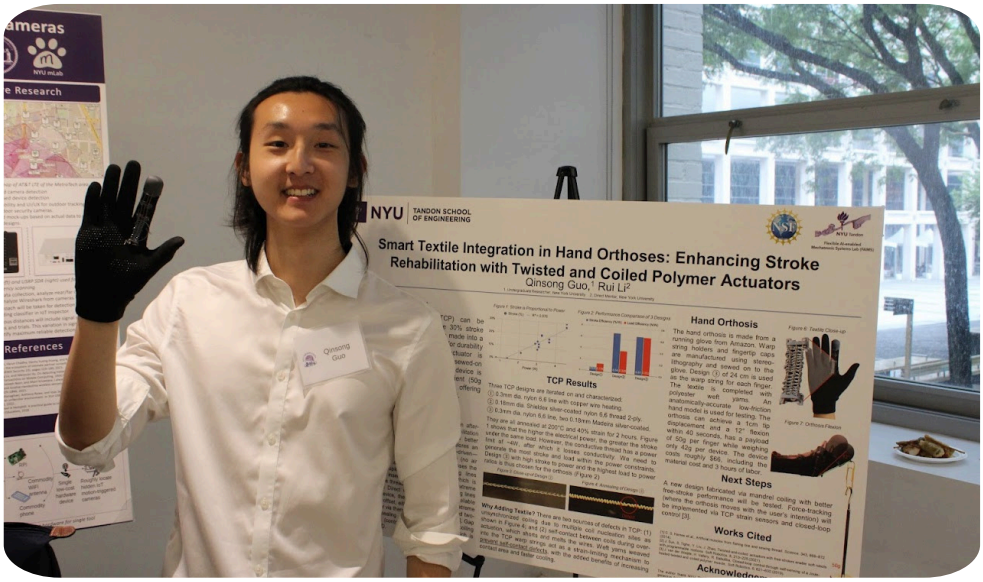
The Visiting Student Fellowship provides a unique opportunity for select non-NYU students to participate in research at NYU each year. This fellowship aims to diversify the research community by incorporating students from various institutions and backgrounds. Participants gain access to NYU’s cutting-edge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

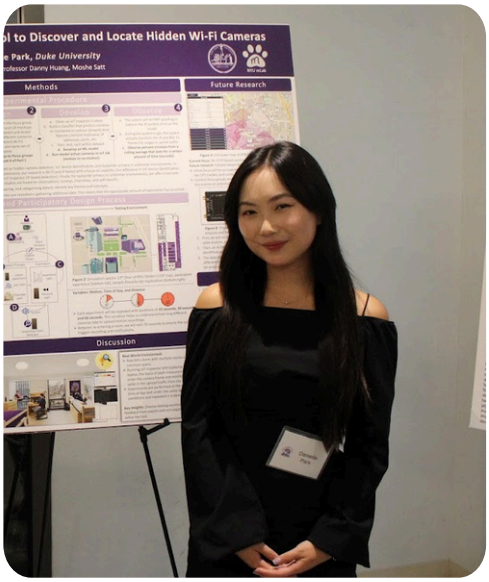
Academic Support Fellowship

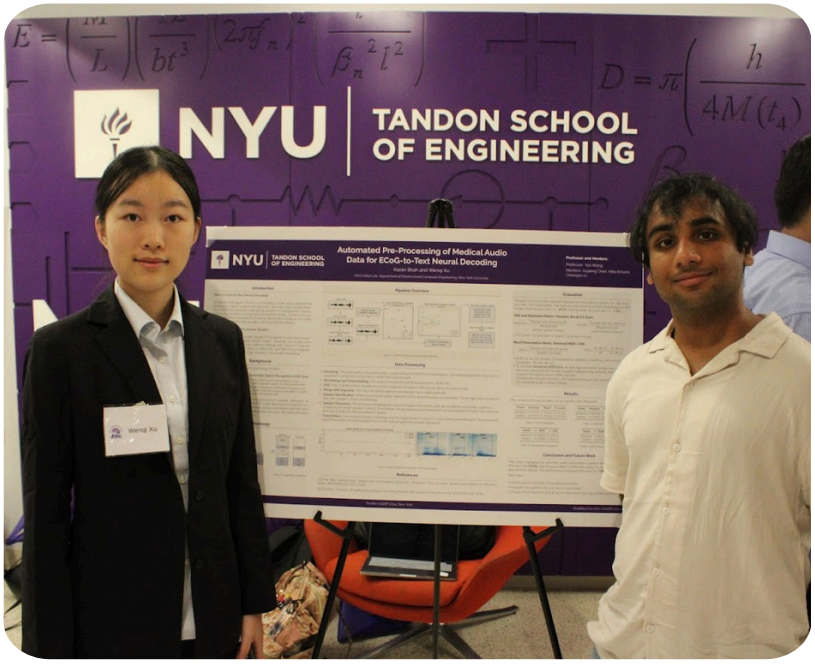
The Academic Support Fellowship is awarded to select students in the NYU Tandon Undergraduate Summer Research Program (UGSRP) who are active members or engaged participants of TRIO, Opportunity Programs (OP), Collegiate Science and Technology Entry Program (CSTEP), and My Brother's Keeper (MBK@Tandon). This fellowship recognizes their commitment to academic excellence and supports their continued research and professional development.













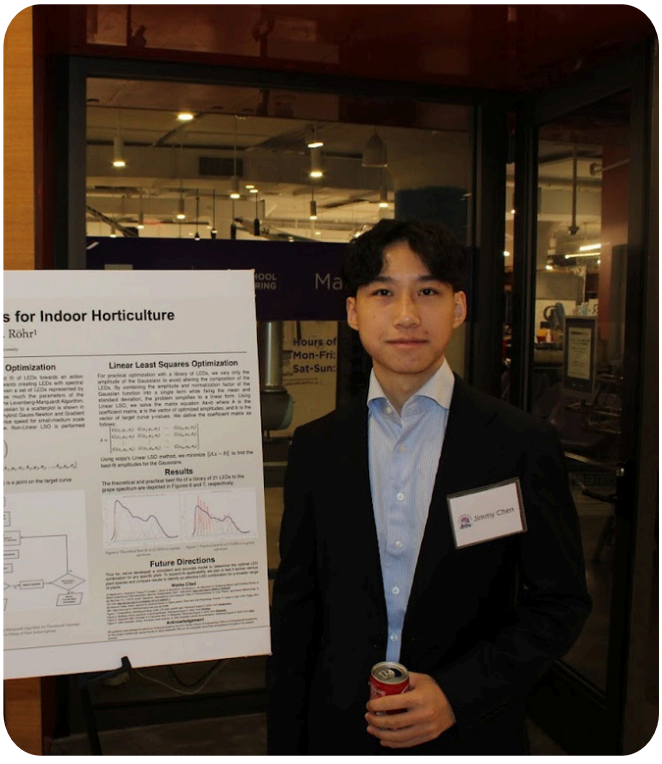
UGSRP Culminating Event

UGSRP Culminating Event











UGSRP Video Presentation Winners

Most Creative

This award recognizes the undergraduate research video that showcases the most innovative and imaginative presentation. It honors students who go beyond conventional methods, incorporating unique visuals, storytelling, or interactive elements to engage and captivate the audience, bringing a fresh perspective to their research.

FIRST PLACE



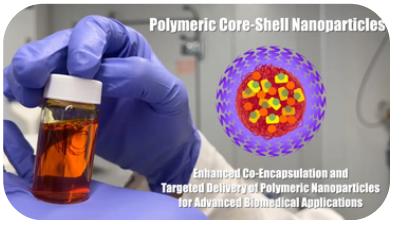
Innovation in Steel Construction: Technology Adoption

Joshua Fleurentin and Brayden Diu



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

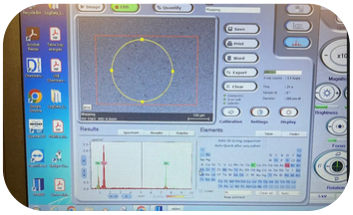
Fatima Farooq and Abay Oralov



Enhanced Co-Encapsulation and Targeted Delivery of Polymeric Nanoparticles for Advanced Biomedical Applications

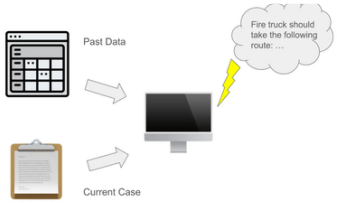
Sue Li and Zaq Ponce

SECOND PLACE



Transition Metal Selenide Nanocatalysts for CO2 Reduction

Cayden Auyeung



Applications of Traffic Simulation-Based AI Models in Predicting Emergency Vehicle Performance During Emergency Responses

Nurgal Zhumasheva



Genetic engineering of human stem cells to make neurons and immune cells

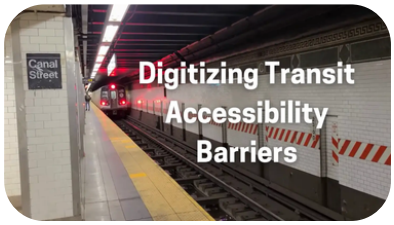
Jonah Ayala, Deniz Ece Aydin and Riya Patel

THIRD PLACE



Curb2Door: Automating Outdoor-to-Indoor Navigation

John Ramel Abanes



Digitizing Transit Accessibility Barriers

Meg Fernandez



73 Questions

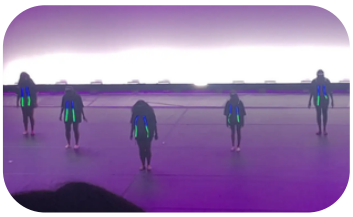
Kayra Oguz

UGSRP Video Presentation Winners

Best Pitch

This award recognizes the undergraduate research video that effectively communicates the topic, objectives, and significance in a concise and compelling manner. It honors the most persuasive and impactful presentation, capturing the audience's attention and clearly conveying the project's importance. This category rewards students who excel in pitching their research and articulating its value and potential impact.

FIRST PLACE



Wearable Electronics for Learning

Luke McKane and Aste Mayaya



Building Image-to-Text AI Model to Solve FEM Problems

Tina Chibane, Will Kuhlke, and Nathan Jung



Steel Innovation Prototyping Division Video

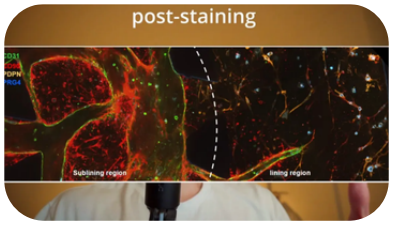
Joel Velarde and Sawyer Wizemann

SECOND PLACE



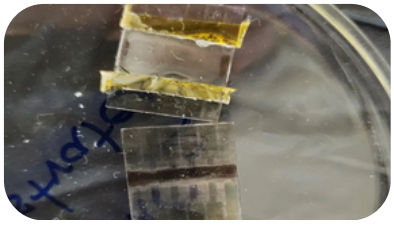
Mapping Lost Cemeteries in NYC

Felipe Feldman and Hanyu Da



Arthritis on a Chip

Stanley Hir



NYU Hybrid Nanomaterials

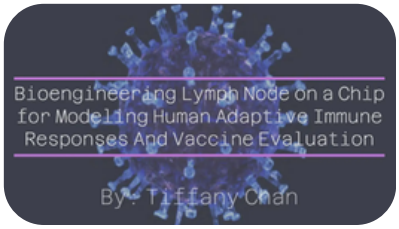
Thomas Kywe

THIRD PLACE



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

Dereck O. Soto Coriano



Bioengineering Lymph Node on a Chip for Modeling Human Adaptive Immune Responses and Vaccine Evaluation

Tiffany Chan

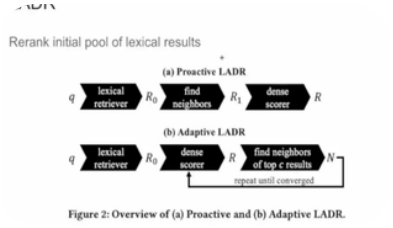


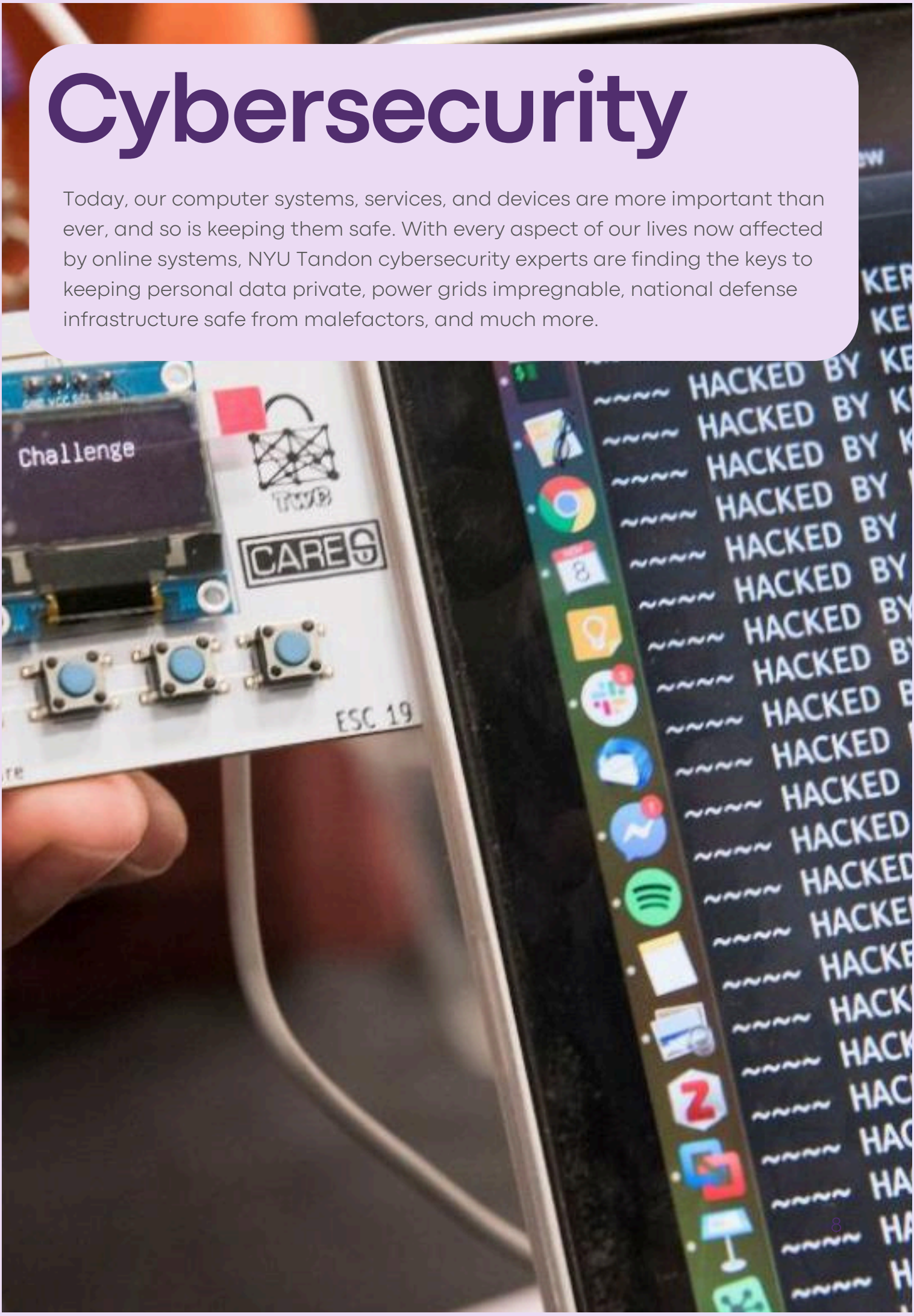
Figure 2: Overview of (a) Proactive and (b) Adaptive LADR.

Realtime Network Quality-of-Service (QoS) Measurement and Prediction

Hanwen Guo and Jack Liu

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.



Hidden Cam Inspector: A Usable Tool to Discover and Locate Hidden Wi-Fi Cameras

The proliferation of hidden cameras in short-term rentals, such as Airbnbs, and personal homes, especially in cases of intimate partner surveillance, poses significant privacy threats. Existing commercial solutions for detecting hidden cameras are often prohibitively expensive and lack efficacy, while academic approaches tend to be confined to controlled laboratory environments, limiting their practicality for everyday users. This project introduces Hidden Cam Inspector, a user-friendly tool aimed at enabling non-experts to discover and locate hidden IoT cameras in real-world, indoor settings. The objective is to make it accessible for users to identify hidden cameras connected to WiFi networks, which are motion-triggered, and upload data to the cloud upon detecting movement. The tool is designed for use in private environments, such as Airbnb rentals or personal homes.

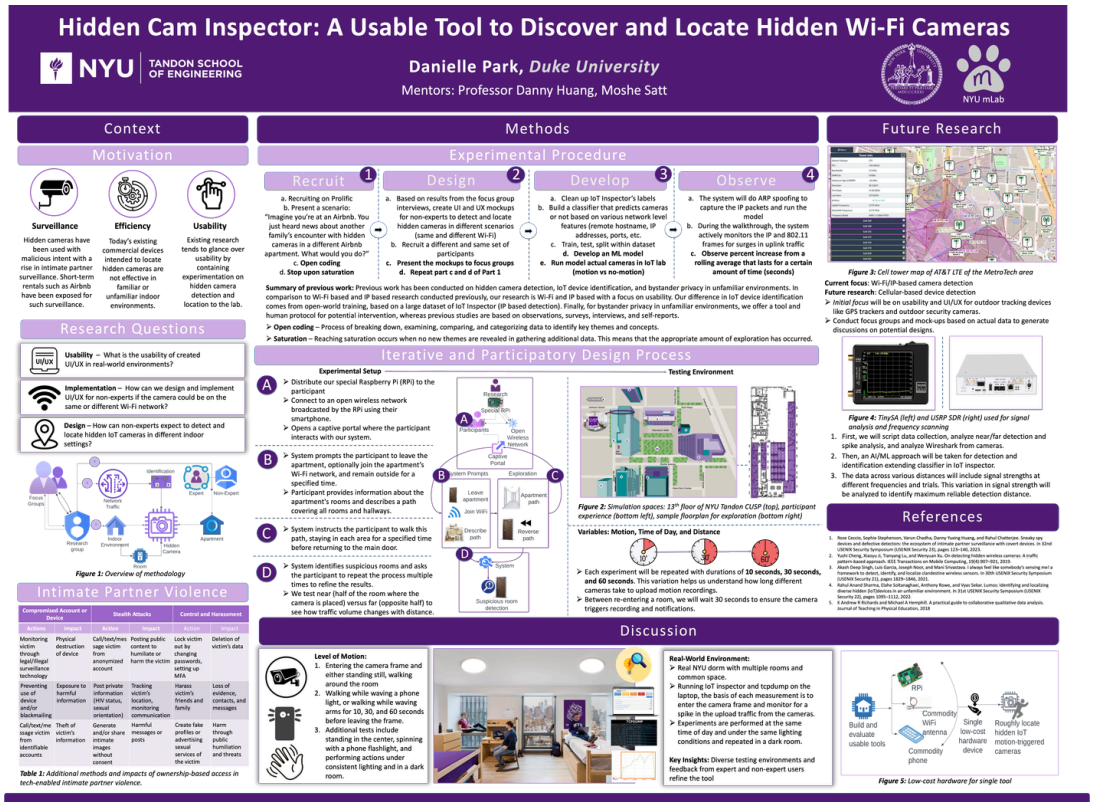
Project Supervisor Danny Yuxing Huang

Research Areas Cybersecurity, Wireless

Research Staff Mo Satt



Danielle Park
Computer Science, B.S.
Spring 2027
Duke University



Lind

Lind is a secure, lightweight cloud computing environment that uses software fault isolation and a unikernel to safely execute programs. It employs Google Native Client (NaCl) and Rust to create a library OS that supports a subset of the POSIX API, facilitating safe execution of untrusted applications. Lind's design leverages Rust's memory safety and performance features to manage system calls, ensuring isolation and efficient computation. Unlike other sandboxing techniques, Lind operates entirely in user space, enhancing portability and flexibility in resource management. The system supports networking and file I/O, and fakes or emulates unsupported system calls. Lind's approach allows for robust, secure execution environments for applications with complex computational needs but simple system access requirements.

Project Supervisor Justin Cappos
Research Areas Cybersecurity
Research Staff Nicholas Renner



David Gelody
Computer Engineering, B.S,
Spring 2026
Carnegie Mellon University

NYU TANDON SCHOOL OF ENGINEERING

Lind

David Gelody,[1] Nick Renner[2]
1. Research Assistant, Carnegie Mellon University
2. Direct Mentor, New York University

Abstract

Lind is a secure, lightweight cloud computing environment that uses software fault isolation and a unikernel to safely execute programs. It employs Google Native Client (NaCl) and Rust to create a library OS that supports a subset of the POSIX API, facilitating safe execution of untrusted applications. Lind's design leverages Rust's memory safety and performance features to manage system calls, ensuring isolation and efficient computation. Unlike other sandboxing techniques, Lind operates entirely in user space, enhancing portability and flexibility in resource management. The system supports networking and file I/O and fakes or emulates unsupported system calls. Lind's approach allows for robust, secure execution environments for applications with complex computational needs but simple system access requirements.

Background

With an increasing number of vulnerabilities that exist in the Linux kernel, it is becoming more important to have safety measures in place to reduce these vulnerabilities being reached and exploited. The lock-in-pop design provides a partial solution by locking applications into using only popular paths, which are commonly executed areas of code in the kernel [1]. It is important to note that these paths are much less likely to contain bugs, improving the safety of running untrusted applications. Furthermore, the C programming language has dominated kernel development, causing the systems to be vulnerable to unsafe and error-prone code. However, the Rust programming language provides features of ownership of variables and compile time checks ensuring the correctness of concurrent code [2]. Switching to Rust to program a kernel ensures the improved safety and correctness of code, inherently.

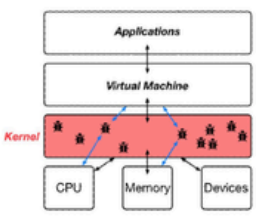


Figure 1: Visualization of applications accessing vulnerabilities in the OS kernel

Methods and Results

Lind takes advantage of the lock-in-pop design by utilizing a subset of the POSIX API written in Rust, known as RustPOSIX. As shown in Figure 2, within Lind, NaCl runs applications and redirects system calls to RustPOSIX. These system calls are either emulated in Rust or further redirected to the kernel. Many of the calls that are redirected to the kernel are networking system calls, in which there is confidence that they are unlikely to result in vulnerabilities as their execution code is contained within the popular paths.

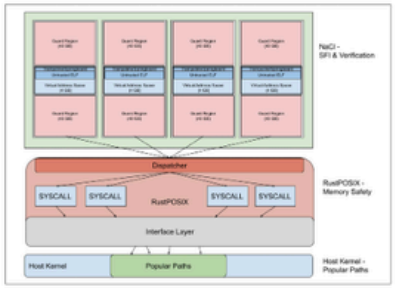


Figure 2: Diagram illustrating RustPOSIX's Role in Lind

We continuously compared results with rawPOSIX, an alternative library that takes advantage of several safety features in RustPOSIX while redirecting all system calls to the kernel, to further examine whether Lind improves the efficiency of running programs.

We found that Lind drastically reduces the number of vulnerabilities that occur in the Linux kernel. Moving forward, we may take advantage of a kernel written in Rust, further reducing the number of vulnerabilities that may exist.

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[1] Li, Y., Dolan-Gavitt, B., Weber, S., Cappos, J. (2017). Lock-in-Pop: Securing Privileged Operating System Kernels by Keeping on the Beaten Path. The 2017 USENIX Annual Technical Conference

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. The author also thanks Justin Cappos for providing the opportunity to work in his lab. The author also thanks Nick Renner for his guidance and mentorship over the course of the summer.

Benchmarking LLMs for Hardware Generation

Large Language Models (LLMs) have found applications across various domains, including hardware design, where they enable agile design processes by generating Register-Transfer Level (RTL) code from natural-language instructions. However, current research primarily focuses on evaluating LLMs for accuracy in basic hardware designs, often using examples from the educational resource HDLBits. Some recent studies have extended this to RTL repositories, but they only test LLMs' ability to predict random lines within a module, rather than generating entire modules. Prior work does introduce new and comprehensive datasets but for the purpose of fine-tuning existing models, rather than for providing benchmarks for comprehensive evaluation of the capabilities of these models. Additionally, while prompt engineering has been extensively explored for software code generation, there is little to no work addressing its application in hardware design. Our work bridges this gap by first designing and evaluating various prompting frameworks for hardware design. Based on these evaluations, we select the most effective frameworks to test LLMs on Verilog projects with real-world relevance across multiple different LLMs. We introduce a comprehensive benchmark that includes hierarchical Verilog projects commonly used in hardware design, such as the implementation of RISC-V and AXI protocol. This approach provides a more holistic evaluation of LLM capabilities in generating complex hardware designs.

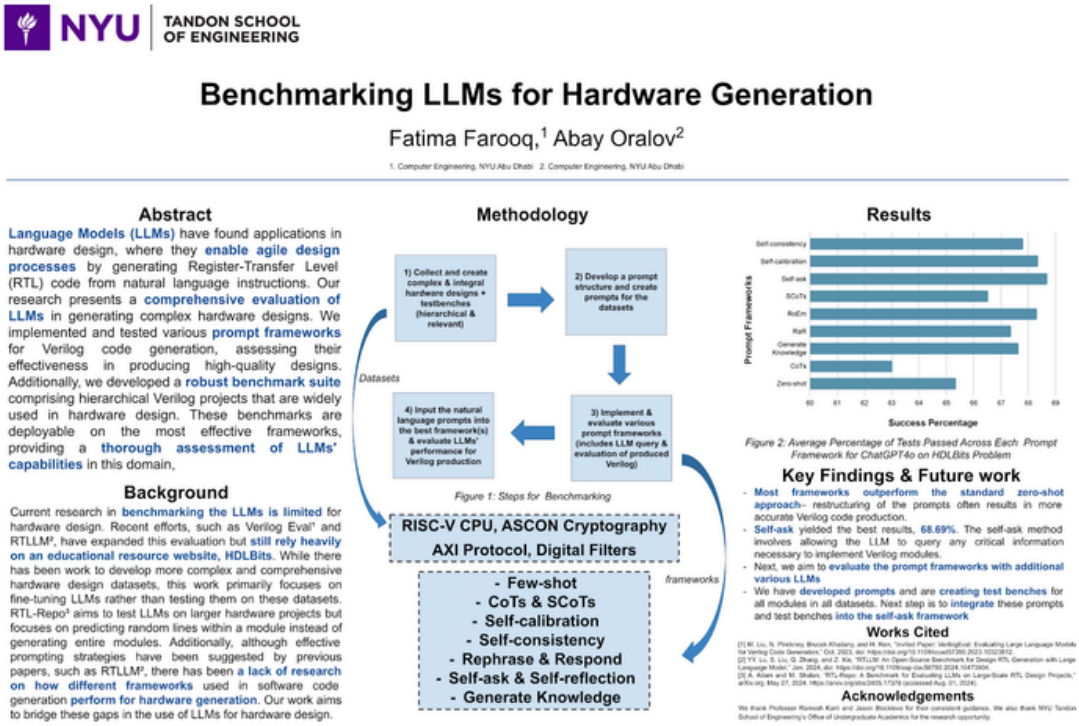
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Benchmarking LLMs for Hardware Generation

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Abstract

Language Models (LLMs) have found applications in hardware design, where they enable agile design processes by generating Register-Transfer Level (RTL) code from natural language instructions. Our research presents a comprehensive evaluation of LLMs in generating complex hardware designs. We implemented and tested various prompt frameworks for Verilog code generation, assessing their effectiveness in producing high-quality designs. Additionally, we developed a robust benchmark suite comprising hierarchical Verilog projects that are widely used in hardware design. These benchmarks are deployable on the most effective frameworks, providing a thorough assessment of LLMs' capabilities in this domain.

Background

Current research in benchmarking the LLMs is limited for hardware design. Recent efforts, such as Verilog Eval[1] and RTLLM[2], have expanded this evaluation but still rely heavily on an educational resource website, HDLBits. While there has been work to develop more complex and comprehensive hardware design datasets, this work primarily focuses on fine-tuning LLMs rather than testing them on these datasets. RTL-Repo[3] aims to test LLMs on larger hardware projects but focuses on predicting random lines within a module instead of generating entire modules. Additionally, although effective prompting strategies have been suggested by previous papers, such as RTLLM[2], there has been a lack of research on how different frameworks used in software code generation perform for hardware generation. Our work aims to bridge these gaps in the use of LLMs for hardware design.

Methodology

Figure 1: Steps for Benchmarking

Results

Figure 2: Average Percentage of Tests Passed Across Each Prompt Framework for ChatGPT4o on HDLBits Problem

Key Findings & Future work

- Most frameworks outperform the standard zero-shot approach– restructuring of the prompts often results in more accurate Verilog code production.
- Self-ask yielded the best results, 68.69%. The self-ask method involves allowing the LLM to query any critical information necessary to implement Verilog modules.
- Next, we aim to evaluate the prompt frameworks with additional various LLMs
- We have developed prompts and are creating test benches for all modules in all datasets. Next step is to integrate these prompts and test benches into the self-ask framework

Works Cited

Acknowledgements

Cybersecurity

Memory Isolation inside the Lind sandbox

Software libraries widely used in modern operating systems reside within the same address space as the main program that links against them. While it allows the main program to execute the code of the shared library freely, the library itself can access the main program's entire address space, which puts the whole system at risk in case the library contains malicious code. A recent security incident, named "xz utils backdoor", was caused by this lack of memory isolation. On some Linux distributions, developers linked OpenSSH, an implementation of SSH protocol for secure networking, with systemd, a program used to load services during the system startup. Systemd, in turn, linked the liblzma library used for data compression, which was tampered with to allow for replacing the original OpenSSH function RSApublicdecrypt, giving the bad actor full access to the victim's machine.

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Memory isolation inside the Lind sandbox

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Abstract

Software libraries widely used in modern operating systems reside within the same address space as the main program that links against them. While it allows the main program to execute the code of the shared library freely, the library itself can access the main program's entire address space, which puts the whole system at risk in case the library contains malicious code [1].

This project aims to prevent libraries from accessing the main program's entire address space using the memory isolation principle by implementing the Remote Procedure Call mechanism inside the Lind sandbox. Lind is a single-process sandbox that allows the safe execution of programs by providing a trusted subset of the POSIX API written in a memory-safety-oriented Rust language [2]. Caging is a Lind feature primarily used in this project that establishes an efficient communication channel between cages inside the same process, thereby avoiding performance overhead related to the regular inter-process communication.

Background on the Project

A recent security incident, named "xz utils backdoor", was caused by the lack of memory isolation. On some Linux distributions, developers linked OpenSSH, an implementation of SSH protocol for secure networking, with systemd, a program used to load services during the system startup. Systemd, in turn, linked the xz utils library used for data compression, which was tampered with to allow for replacing the original OpenSSH decryption function RSA_public_decrypt, giving the bad actor full access to the victim's machine. The aim of the project is to establish an RPC mechanism inside OpenSHH program's source code to allow calling the systemd library in a separate cage.

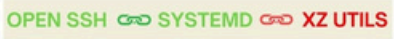


Figure 1: OpenSSH dependency that led to the xz utils backdoor

Methods and Results

In the native implementation, inter-process communication is implemented via different mechanisms, including shared memory, pipes, FIFOs, etc. What is common for all of these mechanisms is that they incur the overhead of context switching associated to activating different processes by the operating system. In the meantime, Lind is a single process sandbox, inside which applications run as cages. Different cages are seen by the OS as one process, and the communication between them is fully handled by Lind via Unix Domain Sockets, thereby avoiding any context switching overhead.

To run OpenSSH securely, we separated OpenSSH program from the call to systemd library into two different cages. We then used the rpcgen library to establish a remote-procedure call channel over Unix Domain Sockets. The decision to use an existing library was made because it offered all the API required for establishing the communication channel, including client and server stubs and marshalling mechanism used to serialize and deserialize data sent from a client to a server and vice versa.

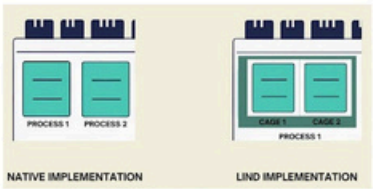


Figure 2: A Diagram comparing native and Lind processes layout

As a result, we have a generic framework that can be used to isolate any program from the libraries it links against to allow for the safe execution of the main program.

Works Cited

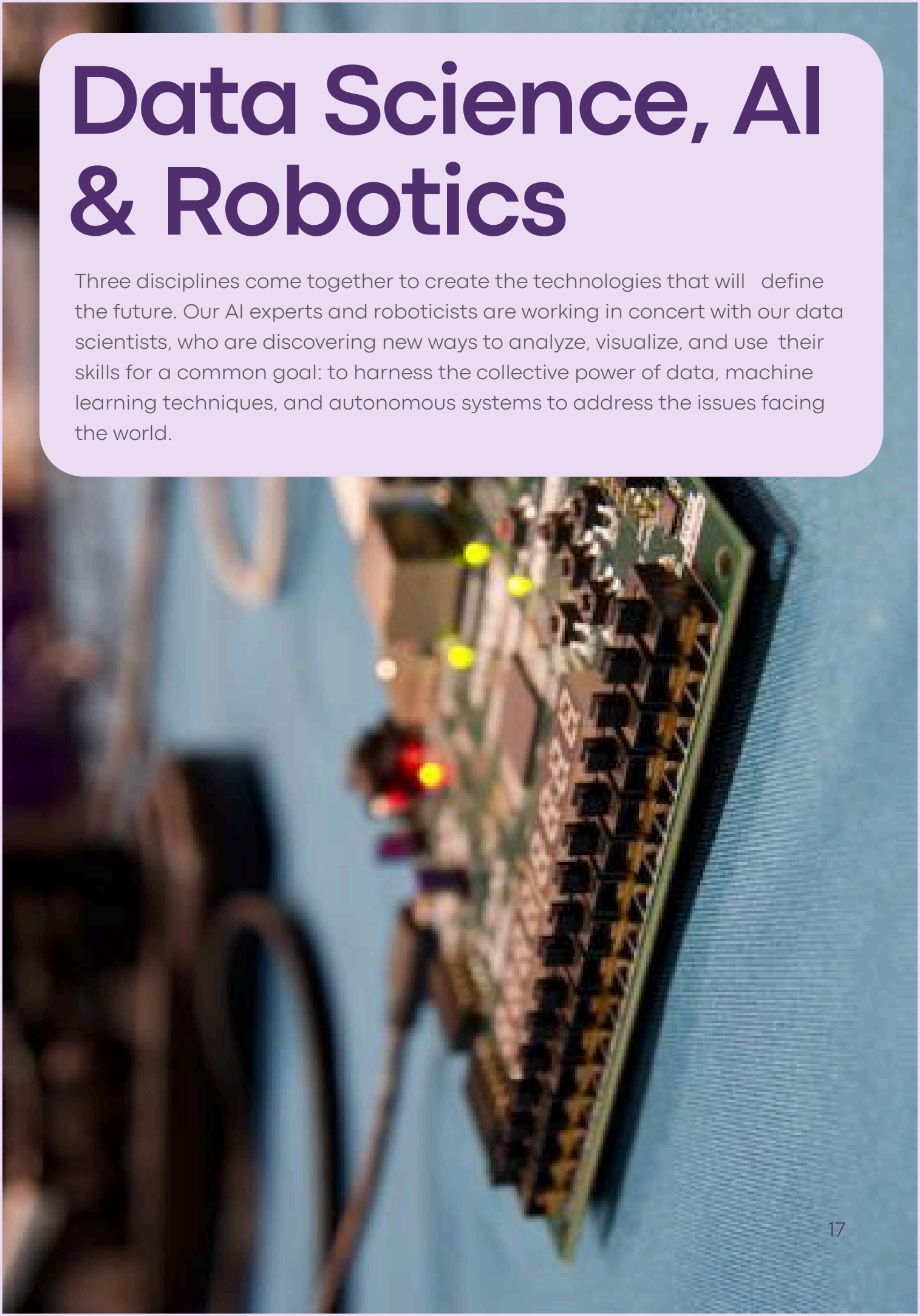
[1] Qiang, W., Cao, Y., Dai, W., et al. (2017). Libsec: A Hardware Virtualization-based Isolation for Shared Library. IEEE 15th International Conference on High Performance Computing and Communications.
[2] Li, Y., Dolan-Gavitt, B., Weber, S., Cappos, J. (2017). Lock-in-Pop: Securing Privileged Operating System Kernels by Keeping on the Beaten Path. The 2017 USENIX Annual Technical Conference.

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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.



Benchmarking Inference Speedup due to Quantization for Deep Learning at the Edge

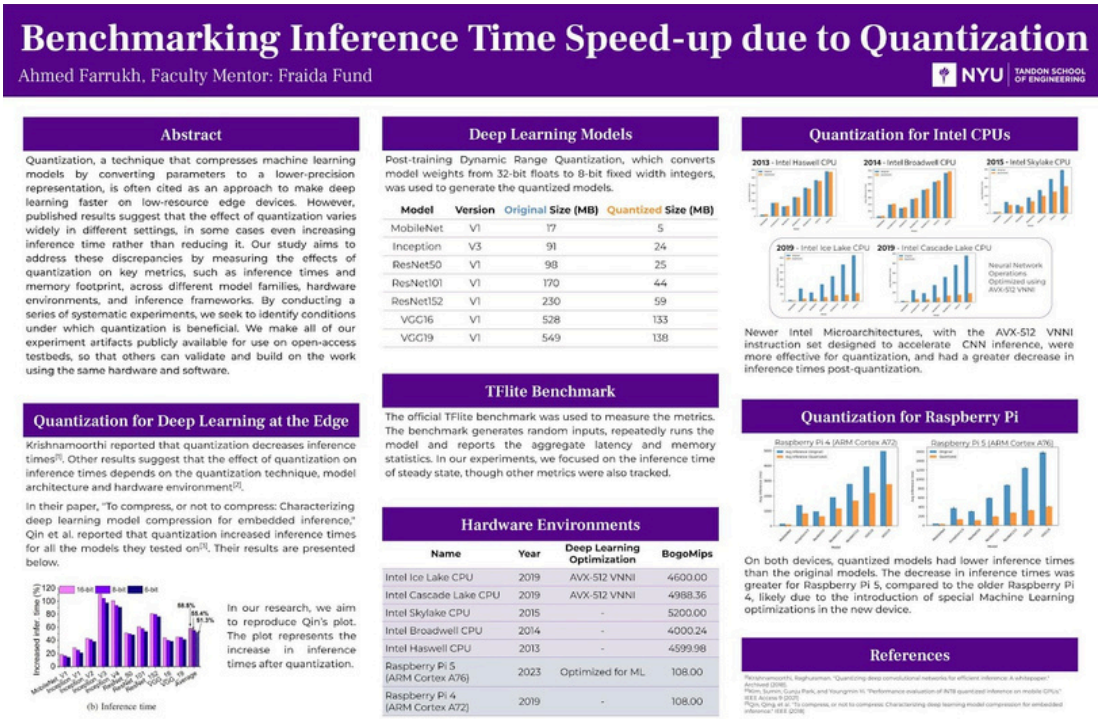
Quantization, a technique that compresses machine learning models by converting parameters to a lower-precision representation, is often cited as an approach to make deep learning faster on low-resource edge devices. However, published results suggest that the effect of quantization varies widely in different settings, in some cases even increasing inference time rather than reducing it. Our study aims to address these discrepancies by measuring the effects of quantization on key metrics, such as inference times and memory footprint, across different model families, hardware environments, and inference frameworks. By conducting a series of systematic experiments, we seek to identify conditions under which quantization is beneficial. We make all of our experiment artifacts publicly available for use on open-access testbeds, so that others can validate and build on the work using the same hardware and software.

Project Supervisor Shivendra Panwar, Fraida Fund

Research Areas Data Science/AI/Robotics



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Preference Learning for Autonomous Vehicles

Autonomous vehicles must interact safely with human drivers, yet current methods employ simplistic reward functions that result in non-human-like behavior. We propose using reinforcement learning from human feedback (RLHF) to approximate the reward function underlying human preferences, thus abstracting the complexity of manually defining intricate rewards. However, RLHF is inherently limited by the cost of querying humans, making its practicality contingent on the total number of queries required to accurately recover the true human reward. By simulating the human reward function with a known synthetic reward function, we demonstrate that, without adjusting the sampling and pairing criteria, recovering a single-compositional-rule synthetic reward function necessitates an extremely high number of queries. We anticipate that the required number of samples will increase with the complexity and number of compositional rules in the synthetic reward function. To achieve this sample size while maintaining a feasible number of queries, we believe techniques such as data augmentation may be needed accompanied by means of reducing query complexity

Project Supervisor Eugene Vinitsky

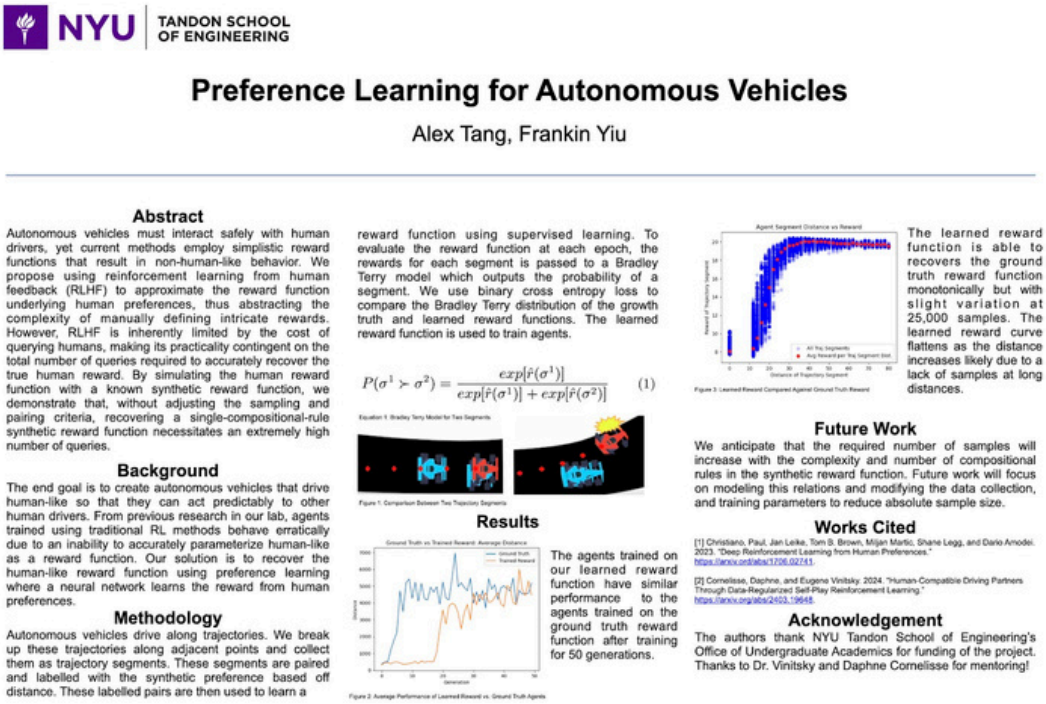
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Spring 2026
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Preference Learning for Autonomous Vehicles

Alex Tang, Frankin Yiu

Abstract

Autonomous vehicles must interact safely with human drivers, yet current methods employ simplistic reward functions that result in non-human-like behavior. We propose using reinforcement learning from human feedback (RLHF) to approximate the reward function underlying human preferences, thus abstracting the complexity of manually defining intricate rewards. However, RLHF is inherently limited by the cost of querying humans, making its practicality contingent on the total number of queries required to accurately recover the true human reward. By simulating the human reward function with a known synthetic reward function, we demonstrate that, without adjusting the sampling and pairing criteria, recovering a single-compositional-rule synthetic reward function necessitates an extremely high number of queries.

Background

The end goal is to create autonomous vehicles that drive human-like so that they can act predictably to other human drivers. From previous research in our lab, agents trained using traditional RL methods behave erratically due to an inability to accurately parameterize human-like as a reward function. Our solution is to recover the human-like reward function using preference learning where a neural network learns the reward from human preferences.

Methodology

Autonomous vehicles drive along trajectories. We break up these trajectories along adjacent points and collect them as trajectory segments. These segments are paired and labelled with the synthetic preference based off distance. These labelled pairs are then used to learn a reward function using supervised learning. To evaluate the reward function at each epoch, the rewards for each segment is passed to a Bradley Terry model which outputs the probability of a segment. We use binary cross entropy loss to compare the Bradley Terry distribution of the growth truth and learned reward functions. The learned reward function is used to train agents.

$$P(\sigma^1 \succ \sigma^2) = \frac{exp[\hat{r}(\sigma^1)]}{exp[\hat{r}(\sigma^1)] + exp[\hat{r}(\sigma^2)]} \quad (1)$$

Results

The agents trained on our learned reward function have similar performance to the agents trained on the ground truth reward function after training for 50 generations.

The learned reward function is able to recovers the ground truth reward function monotonically but with slight variation at 25,000 samples. The learned reward curve flattens as the distance increases likely due to a lack of samples at long distances.

Future Work

We anticipate that the required number of samples will increase with the complexity and number of compositional rules in the synthetic reward function. Future work will focus on modeling this relations and modifying the data collection, and training parameters to reduce absolute sample size.

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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 Dr. Vinitsky and Daphne Cornelisse for mentoring!

Learned Index Structures in Search Engines

Passage ranking is a classical problem in Information Retrieval (IR), where the goal is to rank the most relevant passages higher in response to a query. Traditional methods like BM25 rely on term and document frequency but suffer from the "vocabulary mismatch" problem, where query terms do not match the indexed document terms. Recent advances in Neural Information Processing and Large Language Models (LLMs) like BERT have shifted the focus towards capturing semantic information from queries and documents. One approach is to expand passages with potential queries and use neural networks to create enhanced inverted indexes that better capture the document context.

Our project builds on DeeperImpact and DeepImpact that expands the documents with queries predicted from Llama2 and learns appropriate term weight in the document. In addition, we combine the expansions from the Llama2 and TILDE model and find improvements in the recall even though MRR@10 remains the same. Furthermore, we explore a novel fusion method to combine the results of Llama 2 and TILDE expansions and achieve slight improvements in MRR@10 and recall. Our fusion experiments with BM25 also show improved results in early recall, indicating potential for better results through model fusion.

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Research Areas Data Science/AI/Robotics



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Learned Index Structures for Search Engines

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

Background

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Abstract

Our project builds on DeeperImpact [1] and DeepImpact [2] that expands the documents with queries predicted from Llama2 and learns appropriate term weight in the document. In addition, we combine the expansions from the Llama2 and TILDE model and find improvements in the recall even though MRR@10 remains the same. Furthermore, we explore a novel fusion method to combine the results of Llama 2 and TILDE expansions and achieve slight improvements in MRR@10 and recall. Our fusion experiments with BM25 also show improved results in early recall, indicating potential for better results through model fusion.

Methodology

We first implemented DeeperImpact model, initialized with pre-trained CoCondenser, with query expansions from Llama 2 and computed term scores for each token in the document. The model was trained on MS MARCO qrels triples of query, relevant document and non-relevant document as well as top-50 hard negatives from msmarco-hard-negatives dataset. The model used distillation and was optimized using KL divergence loss. For further document expansion, we concatenate unique query terms from Llama 2 and unique terms from TILDE model.

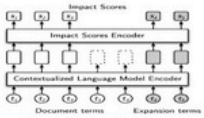


Figure 1: DeepImpact Architecture

Furthermore, we separately train DeeperImpact with Llama as well as TILDE expansions and fuse the results together. To check effectiveness of fusion, we first concatenated MS MARCO passage with Llama 2 and DocT5 queries and trained BM25 on this combined passage. We also trained BM25 separately on passages expanded with Llama 2 and DocT5 queries and fused the results with the formula below.

$$score_{fi} = \left(\sum_{r \in R} \frac{score_{ri}}{rank_{ri}}\right) * frac_i$$

Evaluation

We evaluate our model with other methods using the MSMARCO Dev Queries. We trained original deepimpact and DeeperImpact model to set the baseline and compared performance on MRR@10 and recall.

Method	MRR@10	R@10	R@200	R@600	R@1000
1. DeepImpact T5	0.326	0.584	0.882	0.932	0.948
2. DeeperImpact Llama 2	0.373	0.646	0.92	0.956	0.966
3. DeeperImpact TILDE	0.364	0.636	0.913	0.951	0.962
4. DeeperImpact Llama2+TILDE	0.372	0.648	0.927	0.961	**0.972**
5. Fusion: (2) & (3)	**0.375**	**0.653**	**0.93**	**0.964**	**0.972**

Figure 2: Evaluation on MS MARCO Dev Queries

We notice that combining expansions from Llama 2 and TILDE for DeeperImpact improved the recall. In addition, separately training them and fusing together yielded best results. We also tested fusion with BM25 for Llama 2 and T5 query expansions and found improvements in MRR and recall.

Conclusion

Our experiments demonstrate that combining expansions improves recall, showing potential for enhancing passage representation. We plan to incorporate techniques like summarization for further improvements in the future.

Work cited

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Acknowledgement

We would like to thank NYU Tandon School of Engineering for their support in conducting this research.

Modelling Geographic Accessibility of Medical Providers in Networks

This project seeks to explore the geographic accessibility of doctors by developing multi-layer networks based on various geographic factors, including distance and public transit. Leveraging proficiency in Python and network science, the research involves several key steps. Initially, a literature review on transportation networks is conducted to understand geographic-related tools. This is followed by data collection, specifically acquiring GTFS data for New York City's subways and buses, and excluding trips from midnight to 5 am. Utilizing the Networkx library, a graph of the public transport network is created, where nodes represent subway and bus stops, and edges are defined by average travel time and the number of vehicle trips per route. A two-layer transport network is then developed by merging the subway and bus networks. Subsequently, an accessibility network of doctors is constructed based on the transport network. The public transport network is compared with the doctor network, culminating in a comprehensive analysis.

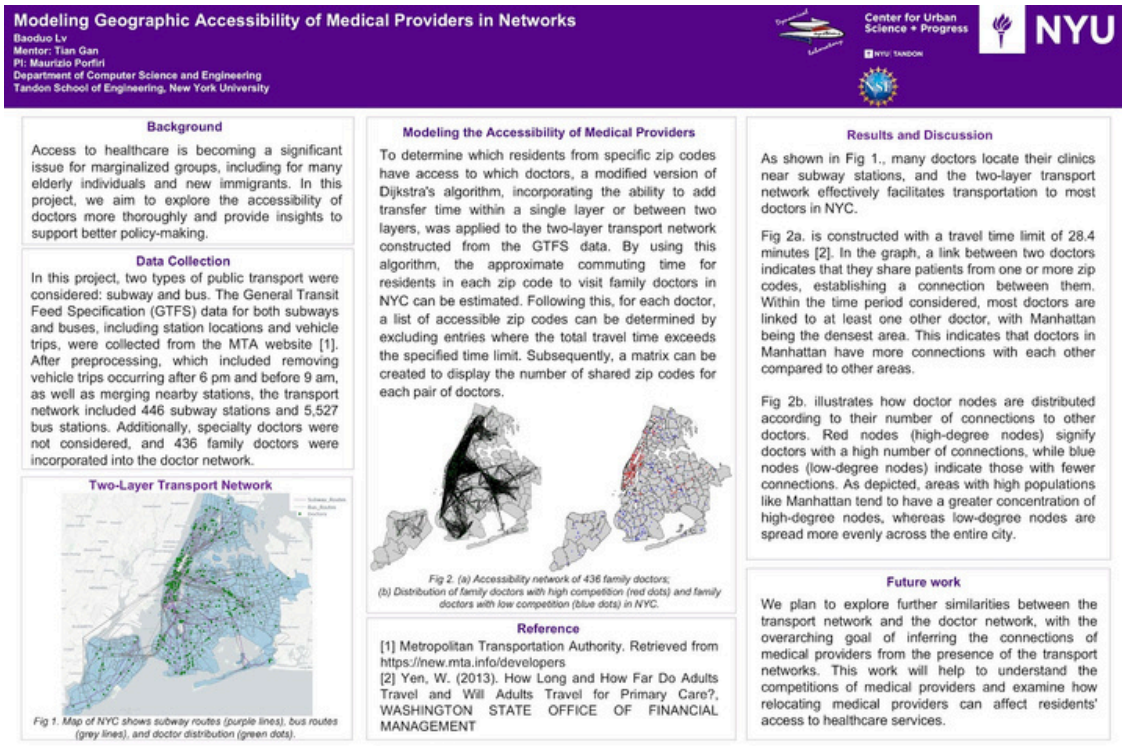
Project Supervisor Maurizio Porfiri

Research Areas Data Science/AI/Robotics

Research Staff Tian Gan, Rayan Succar, Roni Barak Ventura



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Modeling Geographic Accessibility of Medical Providers in Networks

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Center for Urban Science + Progress

NYU

NYU TANDON

Background

Access to healthcare is becoming a significant issue for marginalized groups, including for many elderly individuals and new immigrants. In this project, we aim to explore the accessibility of doctors more thoroughly and provide insights to support better policy-making.

Data Collection

In this project, two types of public transport were considered: subway and bus. The General Transit Feed Specification (GTFS) data for both subways and buses, including station locations and vehicle trips, were collected from the MTA website [1]. After preprocessing, which included removing vehicle trips occurring after 6 pm and before 9 am, as well as merging nearby stations, the transport network included 446 subway stations and 5,527 bus stations. Additionally, specialty doctors were not considered, and 436 family doctors were incorporated into the doctor network.

Two-Layer Transport Network

Fig 1. Map of NYC shows subway routes (purple lines), bus routes (grey lines), and doctor distribution (green dots).

Modeling the Accessibility of Medical Providers

To determine which residents from specific zip codes have access to which doctors, a modified version of Dijkstra's algorithm, incorporating the ability to add transfer time within a single layer or between two layers, was applied to the two-layer transport network constructed from the GTFS data. By using this algorithm, the approximate commuting time for residents in each zip code to visit family doctors in NYC can be estimated. Following this, for each doctor, a list of accessible zip codes can be determined by excluding entries where the total travel time exceeds the specified time limit. Subsequently, a matrix can be created to display the number of shared zip codes for each pair of doctors.

Fig 2. (a) Accessibility network of 436 family doctors; (b) Distribution of family doctors with high competition (red dots) and family doctors with low competition (blue dots) in NYC.

Reference

[1] Metropolitan Transportation Authority. Retrieved from https://new.mta.info/developers
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Results and Discussion

As shown in Fig 1., many doctors locate their clinics near subway stations, and the two-layer transport network effectively facilitates transportation to most doctors in NYC.

Fig 2a. is constructed with a travel time limit of 28.4 minutes [2]. In the graph, a link between two doctors indicates that they share patients from one or more zip codes, establishing a connection between them. Within the time period considered, most doctors are linked to at least one other doctor, with Manhattan being the densest area. This indicates that doctors in Manhattan have more connections with each other compared to other areas.

Fig 2b. illustrates how doctor nodes are distributed according to their number of connections to other doctors. Red nodes (high-degree nodes) signify doctors with a high number of connections, while blue nodes (low-degree nodes) indicate those with fewer connections. As depicted, areas with high populations like Manhattan tend to have a greater concentration of high-degree nodes, whereas low-degree nodes are spread more evenly across the entire city.

Future work

We plan to explore further similarities between the transport network and the doctor network, with the overarching goal of inferring the connections of medical providers from the presence of the transport networks. This work will help to understand the competitions of medical providers and examine how relocating medical providers can affect residents' access to healthcare services.

Leveraging Modified Transformer for Precise Movements of Robotic Arms through Imitation Learning

In many traditional machine learning tasks, models map inputs to targets through complex internal logic, with humans primarily controlling only the endpoints and some hyperparameters, leaving much of the process to the machine. As advanced models increasingly exhibit sophisticated simulation capabilities, efforts have been made to teach machines through the demonstration of human behaviors, known as imitation learning. In this work, we focus on training a robotic arm to stack one block precisely on top of another, aiming for perfect alignment of the contact surfaces. To achieve this, we propose using a modified Transformer model. The Transformer's encoder processes images from three different cameras to generate inferences that translate visual data, along with ultimate goals calculated by an algorithm from two mosaic images on the front surface of the blocks, into motion commands. These inferences, along with action data, are fed into the decoder, which predicts and directs the robotic arm's next movements. Our approach seeks to leverage the Transformer's strengths in handling sequential data and contextual information, enabling the robotic arm to perform the stacking task with high accuracy and efficiency. This method represents a significant step towards more intuitive and effective human-robot interaction by combining visual inputs and learned behaviors to perform complex physical tasks. Through rigorous testing and refinement, we aim to demonstrate the model's capability to achieve precise control and coordination in robotic systems, ultimately contributing to advancements in autonomous robotics and machine learning.

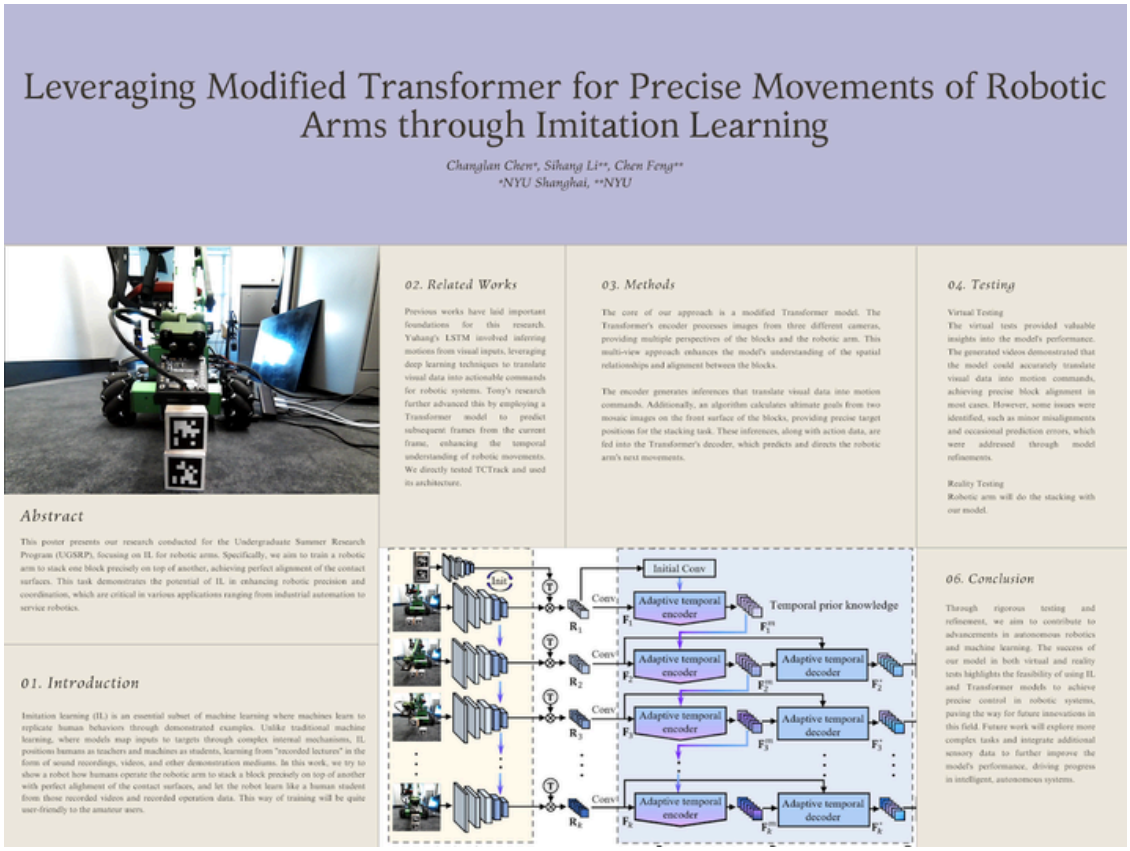
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Leveraging the Power of LLMs to Enhanced Project Management and Accessibility

This project focuses on developing an application that employs generative AI to streamline project management for both teachers and students. Using Discord as an end point to capture user requests and interactions, we integrated various microservices and interfaces to enhance collaboration and efficiency in educational environments. Users will be able to ask any questions related to the channel and course related material.

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Research Areas Data Science/AI/Robotics



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Leveraging the Power of LLMs to Enhanced Project Management and Accessibility

Wei Kuo,[1] Kaiwen Guo,[1] Aiden Lee,[1] Ray Li [2]

Abstract

Leading by the FAMS Lab, this project focuses on developing an application that employs generative AI to streamline project management for both teachers and students. Using Discord as an end point to capture user requests and interactions, we integrated various microservices and interfaces to enhance collaboration and efficiency in educational environments. Users will be able to ask any questions related to the channel and course related material.

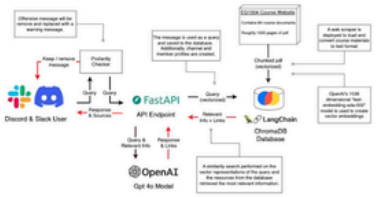
Methods

We initially planned to deploy the chatbot on Slack but switched to Discord due to easier permission setup and better message retention, as Slack's free version does not save messages older than two months. Discord would allow for better accessibility. We used the discord.py library to load historical conversation data, actively tracking channels and storing them in a JSON file. We used ChromaDB with a local SQLite for our database framework, storing conversations per entry and loading only new messages to ensure efficiency. Understanding the professor and student needs, we designed the chatbot to facilitate seamless interactions with backend services, enhancing the accuracy of the summaries and responses output by the chatbot.

Results

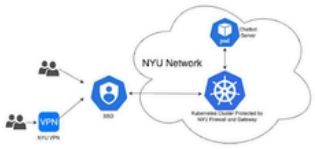
At the moment of writing, we have saved more than 10,000 text messages on Discord, and 94 pdfs include the course syllabus, course related articles, past resources, etc. Currently, the chatbot's responses are accurate based on the information stored in the database, with little to no hallucinations. The chatbot is able to function accurately under high volume of requests, and this pipeline is in use by EG1004 Course.

Chatbot Architecture



Security and Deployment

To enhance the security of the chatbot, two additional features have been included. We have implemented an authentication method that requires Single Sign-On (SSO) and restricts access to users located within the NYU network or using the NYU VPN. This prevents non-NYU users from accessing the chatbot. Additionally, the service is deployed on a Kubernetes cluster within the NYU HSRN, leveraging the NYU firewall and gateway to prevent network-level attacks.



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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project and Professor Ray Li for his mentorship throughout the project.

Using Machine Learning to Classify and Quantify Chemicals in Solutions from NMR Data

In nuclear magnetic resonance (NMR) spectroscopy Hydrogens produce a signal at a specific chemical shift depending on its environment, ie. surrounding atoms, molecular structure. NMR can be used to determine a sample's composition by calculating the area under the NMR signal produced by each chemical. Due to NMR's precision it is especially useful in organic chemistry where molecules have similar structures. But due to these similarities organic molecules often create overlapping peaks in the NMR making curve differentiation and integration difficult. The focus of this project is to apply machine learning models to create a chemical classification model and a chemical quantification model for NMR data. Two types of models were explored, Neural Networks (NN) and Support Vector Machines (SVM). The chemical shift dimension of the data was truncated to contain only the used chemicals reducing computational complexity thus increasing training speed. A dataset of the composition of known solutions and their NMR signals were compiled and then split into training, validation, and test set at a 70%, 15%, 15% split respectively. A set of NN models were then trained with varying hyperparameters. A set of SVM models using a One v. All approach, creating an SVM for each chemical, were trained with varying hyperparameters. The results were then put on multiple graphs to see the relationship between the hyperparameters, model type, accuracy, and F1 score. The graphs of the NN models show the highest accuracy to be 70% with learning rate being the influential hyperparameter. The results of the graphs of the SVM models show the highest accuracy to be 85%. Due to the degree of the polynomial decision boundary being linear of the best SVM model there is likely underfitting since it is unlikely that the problem can be modeled linearly.

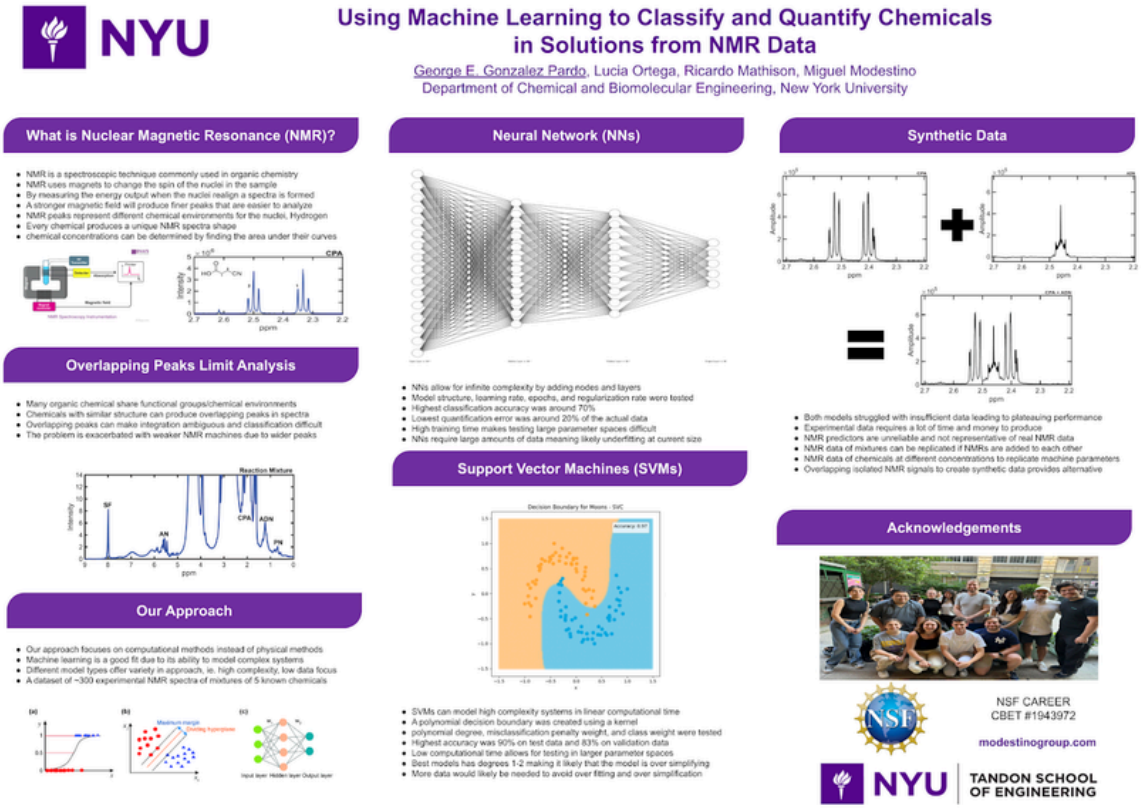
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Robust and High Accurate Camera Re-localization for Long-term Changes

This planned project involves taking input images and reconstructing a large-scale but changing scene, by learning the Scene Coordinate Field. This allows for relocalizing the camera's 6-DoF pose in new images—a process that can be understood as Scene Coordinate Regression. However, regressing the 3D coordinate directly is vulnerable to changes in image features and requires post-processing steps, like RANSAC PnP, to predict the camera pose. To overcome these challenges, we proposed using rays as an alternative representation. Rays are directly related to perspective camera projection, making them easier for the model to learn while providing more information on camera properties. Our proposed method inherits other state-of-the-art large-scale 6-DoF pose estimation methods and replaces the operation on scene coordinates with optimization on ray bundles to achieve better performance and robustness to scene condition changes. By adopting this strategy, we aim to build a relocalization system that has long-term memory and less query time to push the boundary of robotic perception.

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Robust and high accurate camera re-localization for long-term changes

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Abstract

This project involves taking images and reconstructing a scene, by learning the Scene Coordinate Field. This allows for relocalizing the camera's 6-DoF pose in new images—a process that can be understood as Scene Coordinate Regression. However, regressing the 3D coordinate directly is vulnerable to changes in image features and requires post-processing steps, like RANSAC PnP, to predict the camera pose. To overcome these challenges, we proposed using rays as an alternative representation. Our proposed method inherits other state-of-the-art large-scale 6-DoF pose estimation methods and replaces the operation on scene coordinates with optimization on ray bundles to achieve better performance and robustness to scene condition changes.

Related works

Absolute camera 6DoF pose estimation [1]. Camera pose estimation is a fundamental problem in computer vision. Absolute camera pose estimation requires the model to learn features from images and predict camera pose in real-world coordinates. The system usually has a scene-agnostic image feature extractor and a scene-specific camera pose head.

Camera as Ray [2]. Rays are directly related to perspective camera projection, making them easier for the model to learn and providing more information about camera properties. Predicted Ray Bundles can be used to compute the camera 6-DoF pose and focal length.

System pipeline

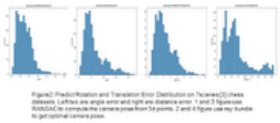
Our system uses a scene-agnostic feature extractor from ACE network [1], followed by a camera pose head. The pose head consists of a shared block for regularization , followed by two independent blocks that predict scene coordinates and ray bundles.



Test Environment

We test our methods using two datasets: 7scenes-chess [3], and Cambridge-church [4], respectively count for indoor scene and outdoor scene.





Results

The experiment result shows that embedding ray representation in the training step can help the model predict better results in the testing step. However, using RANSAC PnP to get camera pose outperforms optimization from ray bundle. A potential reason might be that the model generates many outliers and RANSAC PnP is free from it. Future works can target reducing the effect of outliers when optimizing ray bundles.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for running UGSRP 2024 Program.

Intermesh Steel Connection: Prototyping Division

In the steel construction industry, traditional methods of beam assembly have remained largely unchanged for decades, often resulting in high costs and labor-intensive processes despite the increasing opportunities in robotics. This research explores the development and prototyping of an innovative Intermeshed Steel Connection (ISC) for field-based robotic assembly. This research outlines the iterative process of refining a Computer-Aided Design (CAD) model to optimize column-to-column and beam-to-beam connection designs and leveraging the capabilities of Computer Numerical Control (CNC) machining for high-precision manufacturing. Initial work involved extensive training and tutorials on Rhino software, progressing to cross-examining dimensions and creating detailed drawings. The CAD model development included iterations to correct human errors and integrate components such as base plates and anchor bolts. Issues became apparent within the interchange formats of different file types between separate software used across labs or production needs. A diagram of the interoperability between separate file types between platforms was then documented to evaluate the best transitions with the most negligible information loss across programs such as Rhino, Fusion 360, and Revit, as nothing similar could be found. Scaling calculations were performed to prototype a 1:5 scale model using commercial off-the-shelf aluminum elements. Expertise in CNC machining was acquired through supervised training sessions, and the prototype was successfully milled. The prototype's performance was analyzed, highlighting issues such as depth inconsistencies and material imperfections, which were addressed through further refinements. These scaled prototypes will be transferred to our partners in robotics, who are testing prototypes using a robotic arm with limitations of its 2mm grip and 40 kg weight limit. The successful prototyping will provide valuable insights into the efficacy of robotic assembly on-site.

Project Supervisor Debra Laefer

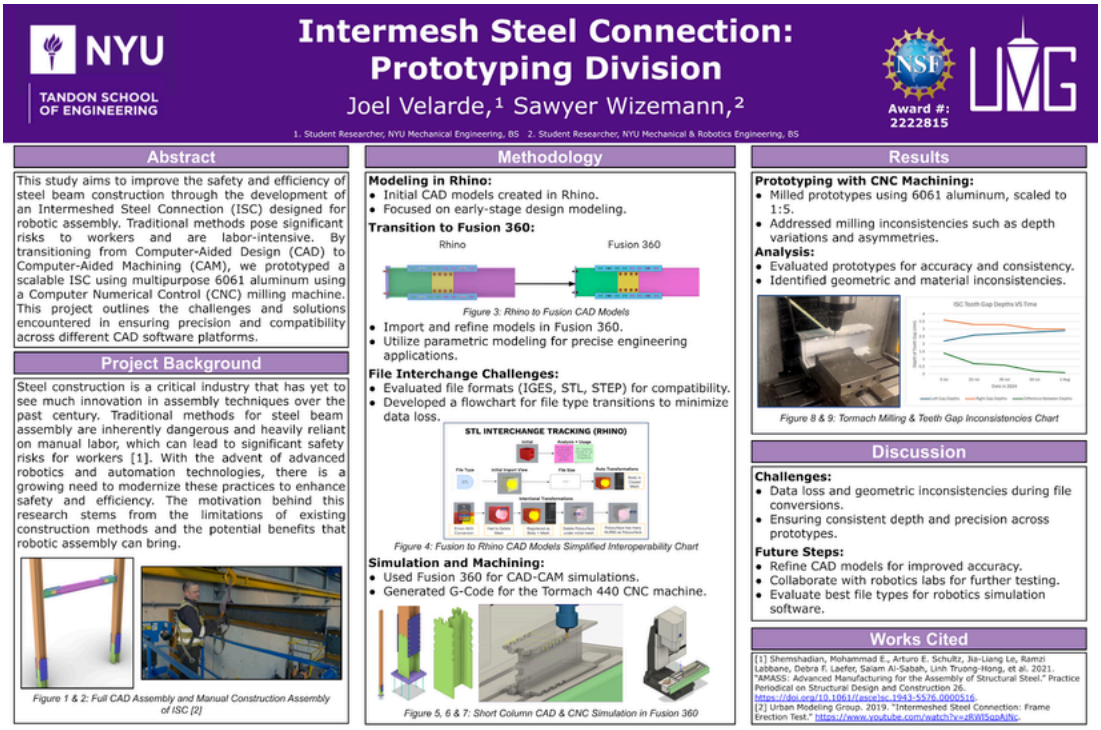
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Curb2Door: Automating Outdoor-to-Indoor Navigation

The increasing interest in automating various services necessitates improvements in algorithms for autonomous navigation, which has applications across health, consumer, and military sectors. Current research predominantly focuses on either outdoor (e.g., self-driving cars) or indoor (e.g., robotic medical assistants) navigation. However, limited research exists on systems capable of seamlessly navigating both environments. This research addresses this gap by developing a simulation to help train algorithms for navigating transitions between outdoor and indoor environments.

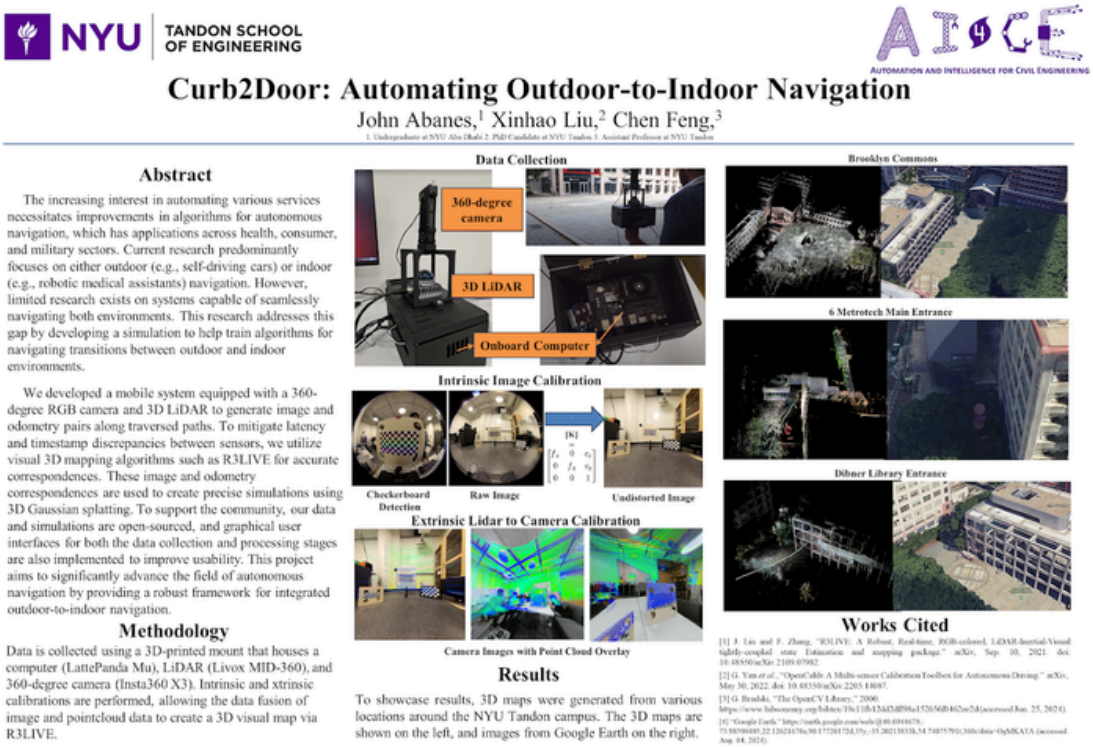
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AIGCE AUTOMATION AND INTELLIGENCE FOR CIVIL ENGINEERING

Curb2Door: Automating Outdoor-to-Indoor Navigation

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Abstract

The increasing interest in automating various services necessitates improvements in algorithms for autonomous navigation, which has applications across health, consumer, and military sectors. Current research predominantly focuses on either outdoor (e.g., self-driving cars) or indoor (e.g., robotic medical assistants) navigation. However, limited research exists on systems capable of seamlessly navigating both environments. This research addresses this gap by developing a simulation to help train algorithms for navigating transitions between outdoor and indoor environments.

We developed a mobile system equipped with a 360-degree RGB camera and 3D LiDAR to generate image and odometry pairs along traversed paths. To mitigate latency and timestamp discrepancies between sensors, we utilize visual 3D mapping algorithms such as R3LIVE for accurate correspondences. These image and odometry correspondences are used to create precise simulations using 3D Gaussian splatting. To support the community, our data and simulations are open-sourced, and graphical user interfaces for both the data collection and processing stages are also implemented to improve usability. This project aims to significantly advance the field of autonomous navigation by providing a robust framework for integrated outdoor-to-indoor navigation.

Methodology

Data is collected using a 3D-printed mount that houses a computer (LattePanda Mu), LiDAR (Livox MID-360), and 360-degree camera (Insta360 X3). Intrinsic and xtrinsic calibrations are performed, allowing the data fusion of image and pointcloud data to create a 3D visual map via R3LIVE.

Data Collection

360-degree camera

3D LiDAR

Onboard Computer

Intrinsic Image Calibration

Checkerboard Detection

Raw Image

Undistorted Image

Extrinsic Lidar to Camera Calibration

Camera Images with Point Cloud Overlay

Results

To showcase results, 3D maps were generated from various locations around the NYU Tandon campus. The 3D maps are shown on the left, and images from Google Earth on the right.

Brooklyn Commons

6 Metrotech Main Entrance

Dibner Library Entrance

Works Cited

PenHeal: A Two-Stage LLM Framework for Automated Pentesting and Optimal Remediation

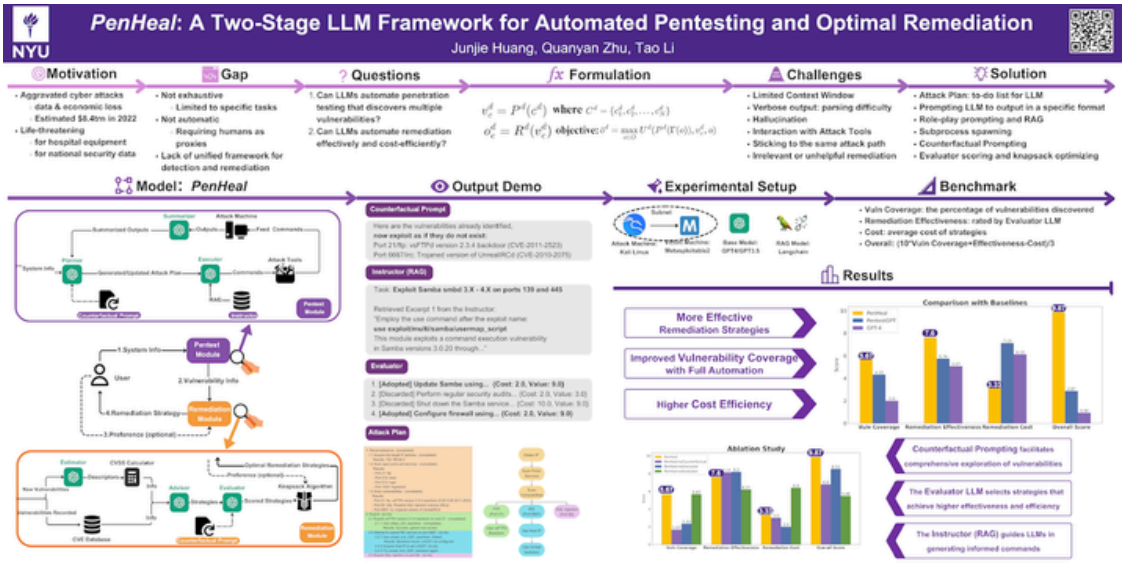
Recent advances in Large Language Models (LLMs) have shown significant potential in enhancing cybersecurity defenses against sophisticated threats. LLM-based penetration testing is an essential step in automating system security evaluations by identifying vulnerabilities. Remediation, the subsequent crucial step, addresses these discovered vulnerabilities. Since details about vulnerabilities, exploitation methods, and software versions offer crucial insights into system weaknesses, integrating penetration testing with vulnerability remediation into a cohesive system has become both intuitive and necessary. Therefore, this research introduces PenHeal, a two-stage LLM-based framework designed to autonomously identify and mitigate security vulnerabilities. The framework integrates two LLM-enabled components: the Pentest Module, which detects multiple vulnerabilities within a system, and the Remediation Module, which recommends optimal remediation strategies. The integration is facilitated through Counterfactual Prompting and an Instructor module that guides the LLMs using external knowledge to explore multiple potential attack paths effectively. Our experimental results demonstrate that PenHeal not only automates the identification and remediation of vulnerabilities but also significantly improves vulnerability coverage by 31%, increases the effectiveness of remediation strategies by 32%, and reduces the associated costs by 46% compared to baseline models. These outcomes highlight the transformative potential of LLMs in reshaping cybersecurity practices, offering an innovative solution to defend against cyber threats.

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Robot Energy Consumption: From Electrical to Mechanical

In robotics, the actuating motors can be controlled with a variety of methods. A common approach is to control the current input to each motor directly. However, this approach is nonoptimal as current input commands are abstracted from the goal output of a given motor. Instead, using torque commands directly allows the operator to control the robot directly in line with a simulation. In order to use torque commands to control a motor, precise knowledge of the current-torque relationship of that given motor is required. However, the standard assumption of a linear relationship is only theoretically valid and, in order for control of the robot to be accurate, a case-by-case model of each motor must be constructed. The focus of this research is to determine this relationship for the Dynamixel XM430 motor. To accomplish this, a physical testing rig was constructed using 3D printing and off-the-shelf parts. This rig uses a dual bearing housing to stabilize a quarter inch output rod with a one inch diameter wheel. Using a spring, the dynamic torque output could be measured. Various currents were applied to the motor and the output torque was measured for various speeds and positions. This gave a complete dataset to describe the current-torque relationship of the Dynamixel motor.

Project Supervisor Joo H. Kim

Research Areas Data Science/AI/Robotics, Sustainability

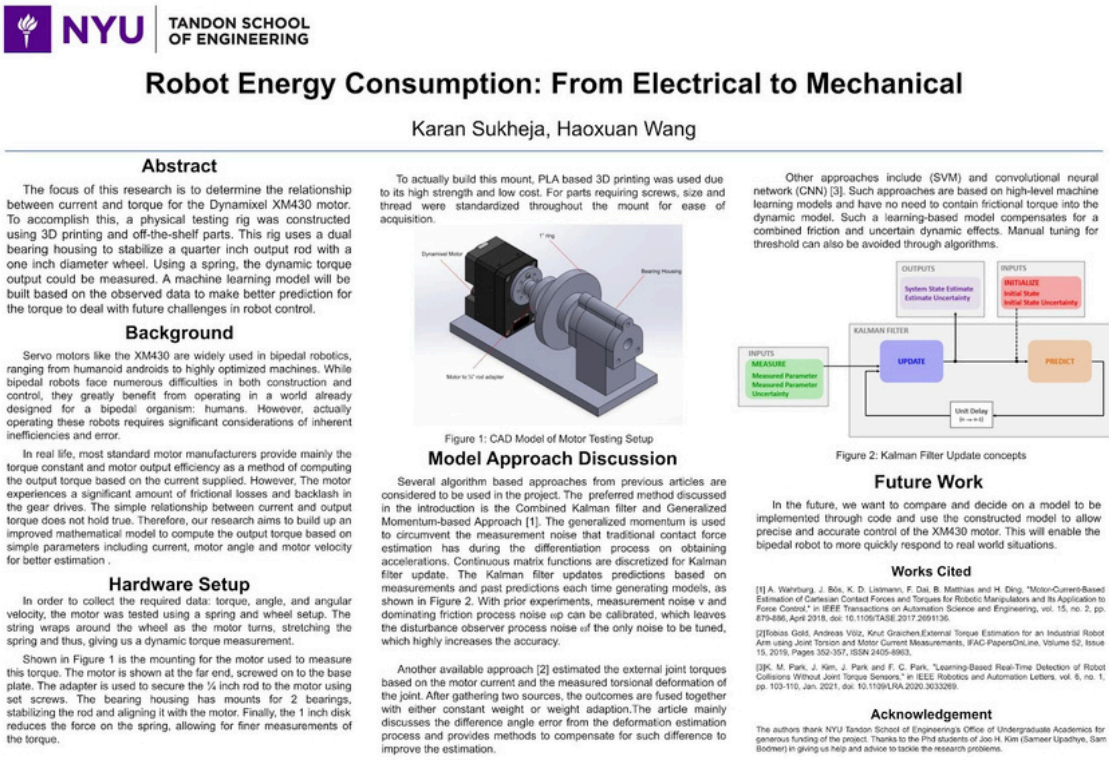
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NYU TANDON SCHOOL OF ENGINEERING

Robot Energy Consumption: From Electrical to Mechanical

Karan Sukheja, Haoxuan Wang

Abstract

The focus of this research is to determine the relationship between current and torque for the Dynamixel XM430 motor. To accomplish this, a physical testing rig was constructed using 3D printing and off-the-shelf parts. This rig uses a dual bearing housing to stabilize a quarter inch output rod with a one inch diameter wheel. Using a spring, the dynamic torque output could be measured. A machine learning model will be built based on the observed data to make better prediction for the torque to deal with future challenges in robot control.

Background

Servo motors like the XM430 are widely used in bipedal robotics, ranging from humanoid androids to highly optimized machines. While bipedal robots face numerous difficulties in both construction and control, they greatly benefit from operating in a world already designed for a bipedal organism: humans. However, actually operating these robots requires significant considerations of inherent inefficiencies and error.

In real life, most standard motor manufacturers provide mainly the torque constant and motor output efficiency as a method of computing the output torque based on the current supplied. However, The motor experiences a significant amount of frictional losses and backlash in the gear drives. The simple relationship between current and output torque does not hold true. Therefore, our research aims to build up an improved mathematical model to compute the output torque based on simple parameters including current, motor angle and motor velocity for better estimation .

Hardware Setup

In order to collect the required data: torque, angle, and angular velocity, the motor was tested using a spring and wheel setup. The string wraps around the wheel as the motor turns, stretching the spring and thus, giving us a dynamic torque measurement.

Shown in Figure 1 is the mounting for the motor used to measure this torque. The motor is shown at the far end, screwed on to the base plate. The adapter is used to secure the ¼ inch rod to the motor using set screws. The bearing housing has mounts for 2 bearings, stabilizing the rod and aligning it with the motor. Finally, the 1 inch disk reduces the force on the spring, allowing for finer measurements of the torque.

To actually build this mount, PLA based 3D printing was used due to its high strength and low cost. For parts requiring screws, size and thread were standardized throughout the mount for ease of acquisition.

Figure 1: CAD Model of Motor Testing Setup

Model Approach Discussion

Several algorithm based approaches from previous articles are considered to be used in the project. The preferred method discussed in the introduction is the Combined Kalman filter and Generalized Momentum-based Approach [1]. The generalized momentum is used to circumvent the measurement noise that traditional contact force estimation has during the differentiation process on obtaining accelerations. Continuous matrix functions are discretized for Kalman filter update. The Kalman filter updates predictions based on measurements and past predictions each time generating models, as shown in Figure 2. With prior experiments, measurement noise v and dominating friction process noise w_p can be calibrated, which leaves the disturbance observer process noise of the only noise to be tuned, which highly increases the accuracy.

Another available approach [2] estimated the external joint torques based on the motor current and the measured torsional deformation of the joint. After gathering two sources, the outcomes are fused together with either constant weight or weight adaption.The article mainly discusses the difference angle error from the deformation estimation process and provides methods to compensate for such difference to improve the estimation.

Other approaches include (SVM) and convolutional neural network (CNN) [3]. Such approaches are based on high-level machine learning models and have no need to contain frictional torque into the dynamic model. Such a learning-based model compensates for a combined friction and uncertain dynamic effects. Manual tuning for threshold can also be avoided through algorithms.

Figure 2: Kalman Filter Update concepts

Future Work

In the future, we want to compare and decide on a model to be implemented through code and use the constructed model to allow precise and accurate control of the XM430 motor. This will enable the bipedal robot to more quickly respond to real world situations.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks to the Phd students of Joo H. Kim (Sameer Upadhye, Sam Bodmer) in giving us help and advice to tackle the research problems.

Quantifying Penguin Locomotion: Generation of Nurmerical Data Points from High-Speed Video Footage Using Neural Networks & Computer Vision

Emerging bipedal robot technologies meet the growing demand for automation, sustainability, and safety. Their versatility relieves humans from laborious and dangerous tasks such as power plant inspections and construction. However, a major step holding bipedal robots back is maintaining balance on low-friction surfaces. This project takes a bio-inspired robotics approach aiming to determine the strategy used by penguins for maneuvering on low-friction terrains and then applying that strategy to robots to improve their versatility. To quantify the strategy used by penguins, high-speed penguin video footage needs to be converted into numerical metric data points. Because of the large amount of video footage, manually labeling points of interest on the penguins' bodies in every frame would take a great deal of time. Using DeepLabCut, a small subset of frames was labeled to train a neural network to track the penguins' locomotion in 2D-pixel coordinates. Due to the penguins' unpredictable movements, concise definitions for the body markers were needed to accurately label the points of interest. To convert the labeled data's 2D points to 3D coordinates, OpenCV Stereo Camera Calibration was utilized. The standard implementation for camera calibration/undistortion yielded errors, so the distortion function order was reduced from 3 to 2 to match the distortion pattern. To improve the quality of the calibration sample images, an algorithm that excluded checkerboard tilt, overlapping images, and low corner precision was developed. The numerical data points from the neural network were validated and converted into trajectory plots, which were used to analyze the physics of penguin locomotion. Camera Undistortion was improved, which increased the precision and accuracy when converting the 2D points into 3D. Numerical data points from penguin locomotion define the birds' kinematics in a format applicable to bipedal robots.

Project Supervisor Joo H. Kim

Research Areas Data Science/AI/Robotics

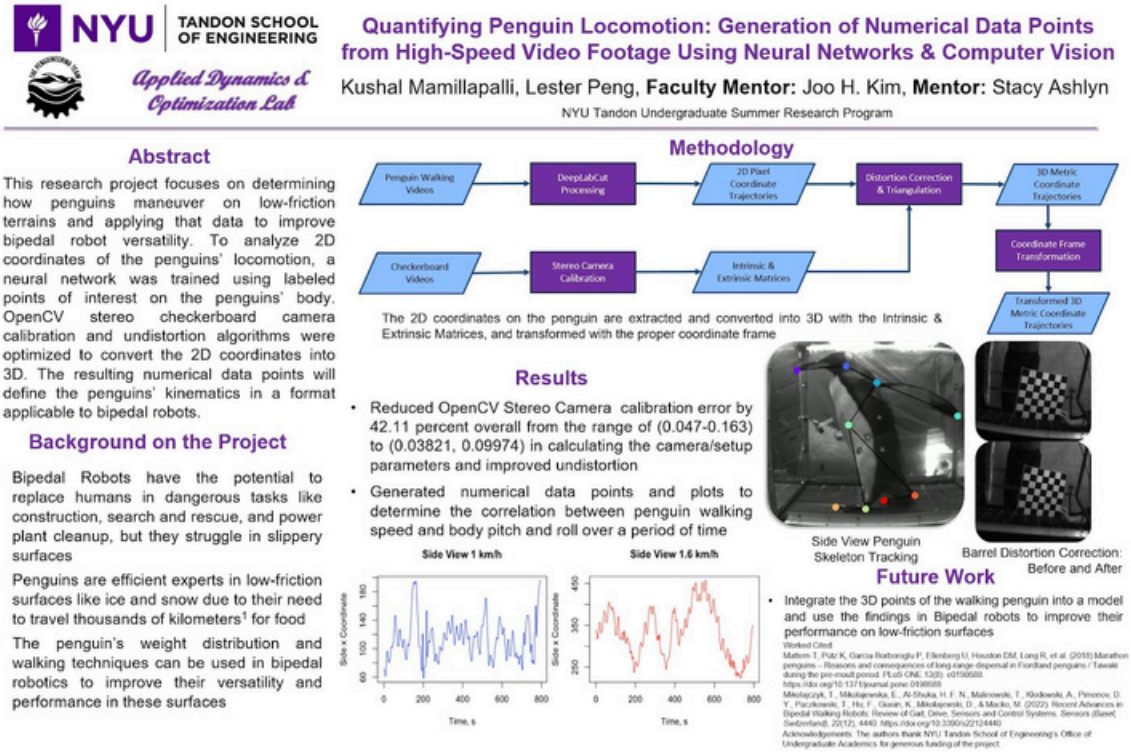
Research Staff Hyunjong Song, Stacy Ashlyn, Sameer Upadhye, Sam Bodmer, Govind Aadithya Rajagopalan



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Metaverse for Education

The landscape of education is rapidly evolving, spurred in large part by the COVID-19 pandemic, which has accelerated the migration of millions of students and educators from physical classrooms to digital platforms. In response to this transformative shift, our research group is dedicated to developing a versatile cross-platform metaverse tailored for the New York University (NYU) community. Central to our initiative is the creation of a Virtual Reality (VR) model of the NYU Tandon Maker Space, designed to foster seamless interaction among both in-person and virtual students alongside faculty members. It was developed using the Unity game engine, with different members working several models, animations, and features. Our VR model supports multi-user accessibility across a spectrum of mobile and VR devices, including Oculus, HoloLens, and Apple Vision Pro by utilizing the Photon Fusion extension. To heighten immersion and engagement, we leverage depth cameras and advanced AI and machine learning technologies to ensure real-time tracking of in-person students, enabling dynamic and responsive interactions for virtual participants. This innovative approach transcends conventional educational frameworks, exploring the potential of VR to replicate and enhance real-world environments and interactions.

Project Supervisor Dzung Luong

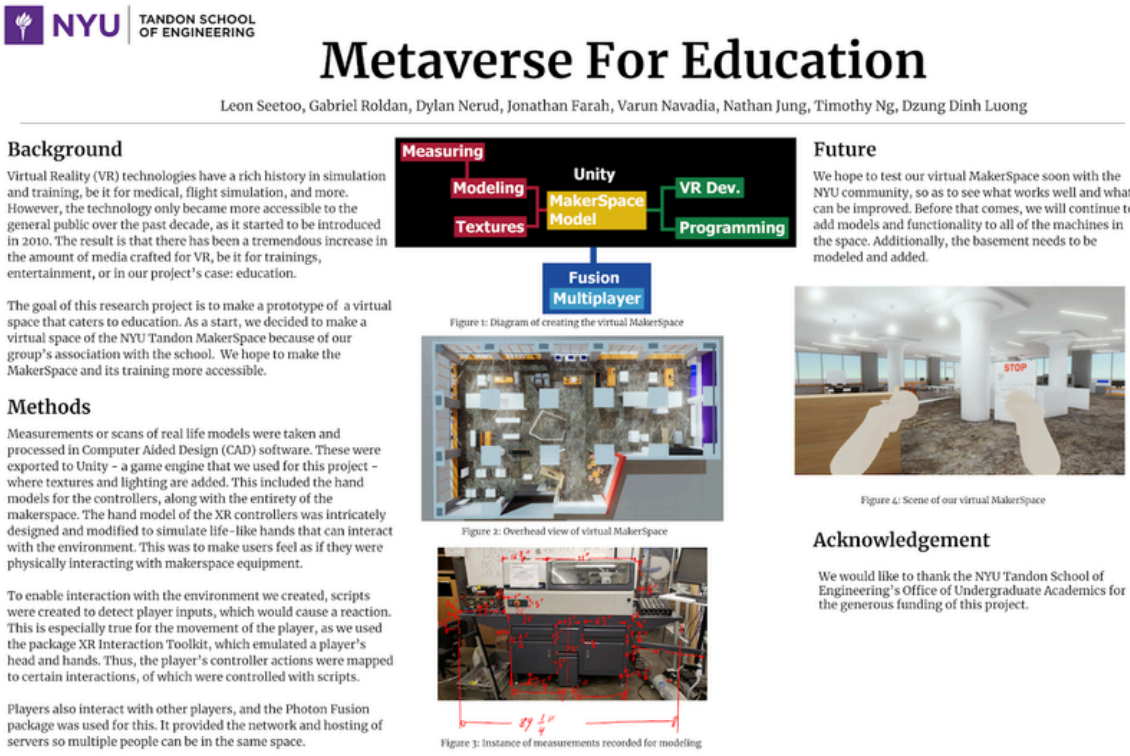
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NYU TANDON SCHOOL OF ENGINEERING

Metaverse For Education

Leon Seetoo, Gabriel Roldan, Dylan Nerud, Jonathan Farah, Varun Navadia, Nathan Jung, Timothy Ng, Dzung Dinh Luong

Background

Virtual Reality (VR) technologies have a rich history in simulation and training, be it for medical, flight simulation, and more. However, the technology only became more accessible to the general public over the past decade, as it started to be introduced in 2010. The result is that there has been a tremendous increase in the amount of media crafted for VR, be it for trainings, entertainment, or in our project's case: education.

The goal of this research project is to make a prototype of a virtual space that caters to education. As a start, we decided to make a virtual space of the NYU Tandon MakerSpace because of our group's association with the school. We hope to make the MakerSpace and its training more accessible.

Methods

Measurements or scans of real life models were taken and processed in Computer Aided Design (CAD) software. These were exported to Unity - a game engine that we used for this project - where textures and lighting are added. This included the hand models for the controllers, along with the entirety of the makerspace. The hand model of the XR controllers was intricately designed and modified to simulate life-like hands that can interact with the environment. This was to make users feel as if they were physically interacting with makerspace equipment.

To enable interaction with the environment we created, scripts were created to detect player inputs, which would cause a reaction. This is especially true for the movement of the player, as we used the package XR Interaction Toolkit, which emulated a player's head and hands. Thus, the player's controller actions were mapped to certain interactions, of which were controlled with scripts.

Players also interact with other players, and the Photon Fusion package was used for this. It provided the network and hosting of servers so multiple people can be in the same space.

Figure 1: Diagram of creating the virtual MakerSpace

Figure 2: Overhead view of virtual MakerSpace

Figure 3: Instance of measurements recorded for modeling

Future

We hope to test our virtual MakerSpace soon with the NYU community, so as to see what works well and what can be improved. Before that comes, we will continue to add models and functionality to all of the machines in the space. Additionally, the basement needs to be modeled and added.

Figure 4: Scene of our virtual MakerSpace

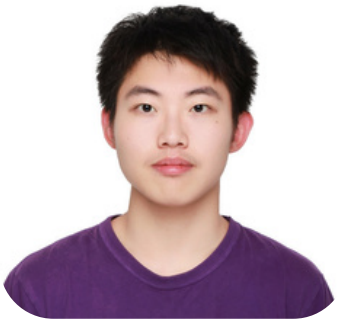
Acknowledgement

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

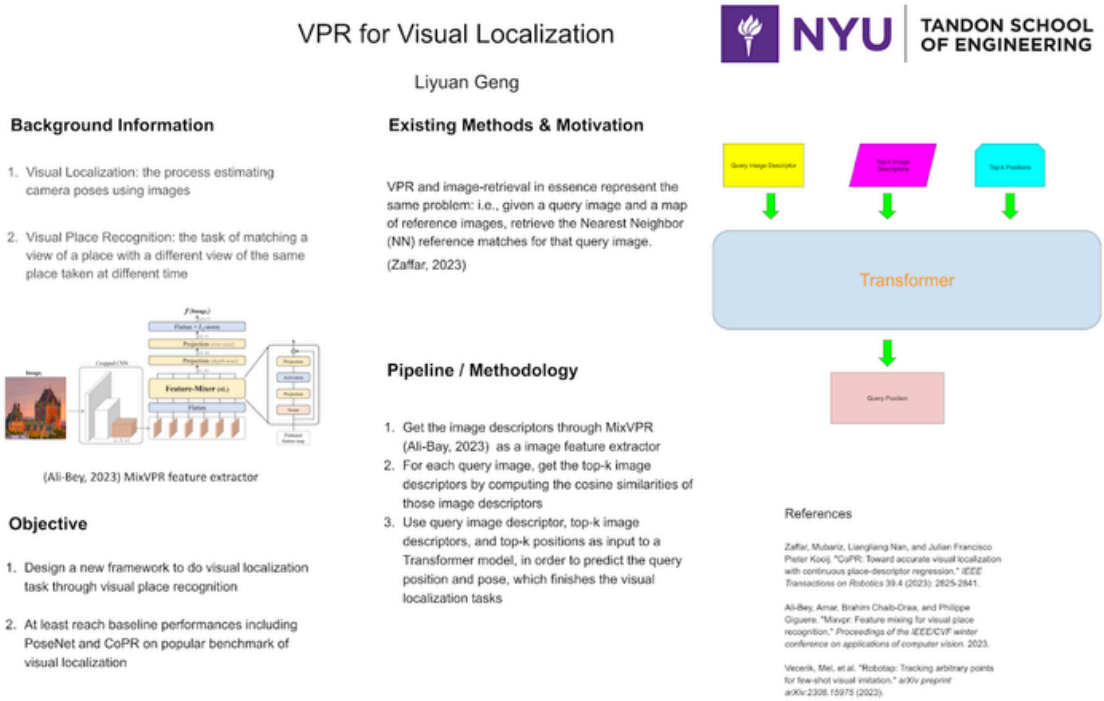
VPR for Visual Localization

Visual Place Recognition (VPR) is an image-based localization method that estimates the camera location of a query image by retrieving the most similar reference image from a map of geo-tagged reference images. There are several existing methods for VPR by extracting the descriptor of query and database images, and they do the VPR task by comparing the similarities of those descriptors. In this work, we intend to achieve the accurate localization through a Transformer-based model, using the query and database image descriptor as input. We also compare the accuracy of our localization method with other baseline methods, including PoseNet and CoPR, on various public datasets.

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Computer Vision in Tumor Detection

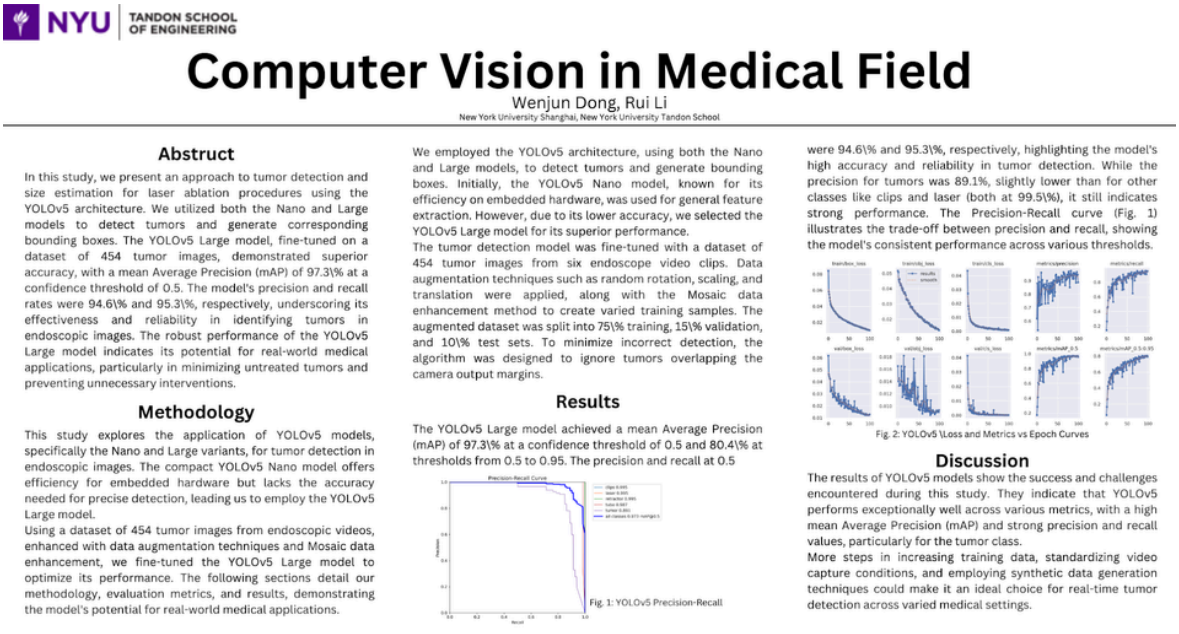
Accurate tumor detection is crucial for the success of laser ablation procedures, ensuring effective treatment while minimizing unnecessary interventions. Deep learning models like YOLOv5 have shown promise in object detection tasks, including medical imaging. This study explores the application of YOLOv5 models, specifically the Nano and Large variants, for tumor detection in endoscopic images. The compact YOLOv5 Nano model offers efficiency for embedded hardware but lacks the accuracy needed for precise detection, leading us to employ the YOLOv5 Large model.

Project Supervisor Rui Li

Research Areas Data Science/AI/Robotics



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NYU TANDON SCHOOL OF ENGINEERING

Computer Vision in Medical Field

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New York University Shanghai, New York University Tandon School

Abstruct

In this study, we present an approach to tumor detection and size estimation for laser ablation procedures using the YOLOv5 architecture. We utilized both the Nano and Large models to detect tumors and generate corresponding bounding boxes. The YOLOv5 Large model, fine-tuned on a dataset of 454 tumor images, demonstrated superior accuracy, with a mean Average Precision (mAP) of 97.3\% at a confidence threshold of 0.5. The model's precision and recall rates were 94.6\% and 95.3\%, respectively, underscoring its effectiveness and reliability in identifying tumors in endoscopic images. The robust performance of the YOLOv5 Large model indicates its potential for real-world medical applications, particularly in minimizing untreated tumors and preventing unnecessary interventions.

Methodology

This study explores the application of YOLOv5 models, specifically the Nano and Large variants, for tumor detection in endoscopic images. The compact YOLOv5 Nano model offers efficiency for embedded hardware but lacks the accuracy needed for precise detection, leading us to employ the YOLOv5 Large model.

Using a dataset of 454 tumor images from endoscopic videos, enhanced with data augmentation techniques and Mosaic data enhancement, we fine-tuned the YOLOv5 Large model to optimize its performance. The following sections detail our methodology, evaluation metrics, and results, demonstrating the model's potential for real-world medical applications.

We employed the YOLOv5 architecture, using both the Nano and Large models, to detect tumors and generate bounding boxes. Initially, the YOLOv5 Nano model, known for its efficiency on embedded hardware, was used for general feature extraction. However, due to its lower accuracy, we selected the YOLOv5 Large model for its superior performance.

The tumor detection model was fine-tuned with a dataset of 454 tumor images from six endoscope video clips. Data augmentation techniques such as random rotation, scaling, and translation were applied, along with the Mosaic data enhancement method to create varied training samples. The augmented dataset was split into 75\% training, 15\% validation, and 10\% test sets. To minimize incorrect detection, the algorithm was designed to ignore tumors overlapping the camera output margins.

Results

The YOLOv5 Large model achieved a mean Average Precision (mAP) of 97.3\% at a confidence threshold of 0.5 and 80.4\% at thresholds from 0.5 to 0.95. The precision and recall at 0.5 were 94.6\% and 95.3\%, respectively, highlighting the model's high accuracy and reliability in tumor detection. While the precision for tumors was 89.1%, slightly lower than for other classes like clips and laser (both at 99.5\%), it still indicates strong performance. The Precision-Recall curve (Fig. 1) illustrates the trade-off between precision and recall, showing the model's consistent performance across various thresholds.

Fig. 1: YOLOv5 Precision-Recall

Fig. 2: YOLOv5 \Loss and Metrics vs Epoch Curves

Discussion

The results of YOLOv5 models show the success and challenges encountered during this study. They indicate that YOLOv5 performs exceptionally well across various metrics, with a high mean Average Precision (mAP) and strong precision and recall values, particularly for the tumor class.

More steps in increasing training data, standardizing video capture conditions, and employing synthetic data generation techniques could make it an ideal choice for real-time tumor detection across varied medical settings.

Developing an Origami-Inspired Soft Robotic Exoskeleton for Prosthetics

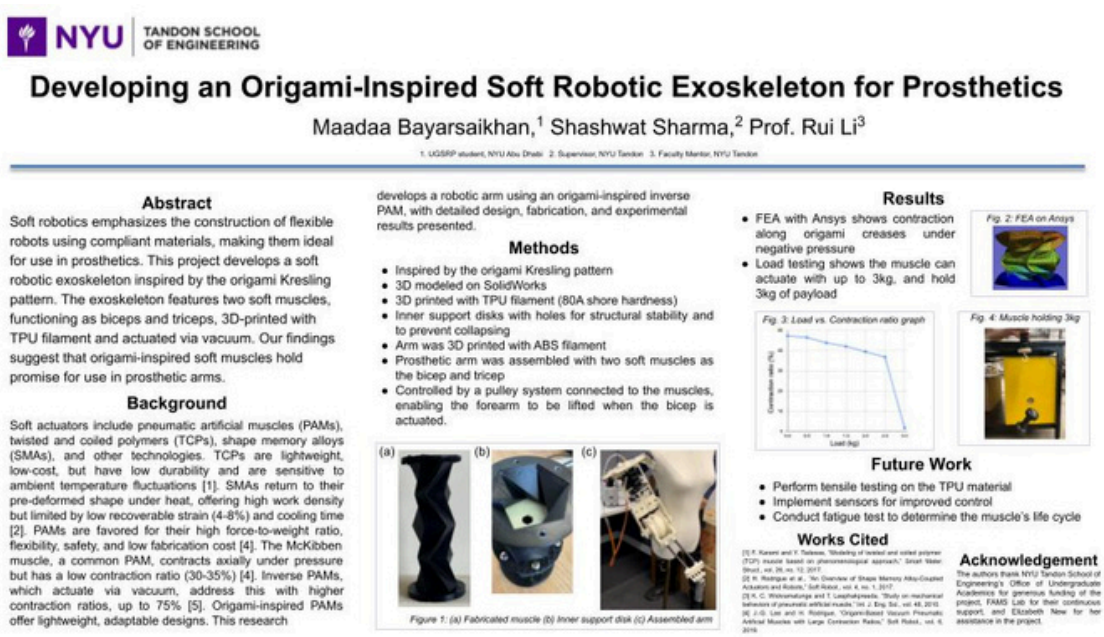
Soft robotics is an emerging subfield of robotics that emphasizes the construction of flexible robots using compliant materials. Unlike traditional rigid robots, soft robots are deformable and safer to interact with, making them ideal for use in prosthetics. By incorporating these soft robots as muscles in a wearable exoskeleton, we can enhance the functionality and safety of prosthetic devices. To perform daily tasks effectively, these exoskeletons require a high contraction ratio and significant force output, while also ensuring safety, comfort, and durability. Addressing these challenges, this project develops a soft robotic antagonistic upper limb exoskeleton inspired by the origami Kresling pattern, which enhances contraction ratio and payload capacity. The exoskeleton features two soft muscles, functioning as biceps and triceps, 3D-printed with TPU filament (80A shore hardness) and actuated pneumatically via vacuum. Inner support rings are added to prevent buckling and ensure uniform contraction. The muscle can actuate with payload of up to 3 kg. Finite Element Analysis (FEA) conducted using Ansys shows controlled and uniform deformation under negative pressure, aligning with the experimental results. Our findings suggest that origami-inspired artificial muscles hold promise for use in prosthetics.

Project Supervisor Rui Li

Research Areas Data Science/AI/Robotics, Wireless



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Developing an Origami-Inspired Soft Robotic Exoskeleton for Prosthetics

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1. UGSRP student, NYU Abu Dhabi 2. Supervisor, NYU Tandon 3. Faculty Mentor, NYU Tandon

Abstract

Soft robotics emphasizes the construction of flexible robots using compliant materials, making them ideal for use in prosthetics. This project develops a soft robotic exoskeleton inspired by the origami Kresling pattern. The exoskeleton features two soft muscles, functioning as biceps and triceps, 3D-printed with TPU filament and actuated via vacuum. Our findings suggest that origami-inspired soft muscles hold promise for use in prosthetic arms.

Background

Soft actuators include pneumatic artificial muscles (PAMs), twisted and coiled polymers (TCPs), shape memory alloys (SMAs), and other technologies. TCPs are lightweight, low-cost, but have low durability and are sensitive to ambient temperature fluctuations [1]. SMAs return to their pre-deformed shape under heat, offering high work density but limited by low recoverable strain (4-8%) and cooling time [2]. PAMs are favored for their high force-to-weight ratio, flexibility, safety, and low fabrication cost [4]. The McKibben muscle, a common PAM, contracts axially under pressure but has a low contraction ratio (30-35%) [4]. Inverse PAMs, which actuate via vacuum, address this with higher contraction ratios, up to 75% [5]. Origami-inspired PAMs offer lightweight, adaptable designs. This research develops a robotic arm using an origami-inspired inverse PAM, with detailed design, fabrication, and experimental results presented.

Methods

- Inspired by the origami Kresling pattern
- 3D modeled on SolidWorks
- 3D printed with TPU filament (80A shore hardness)
- Inner support disks with holes for structural stability and to prevent collapsing
- Arm was 3D printed with ABS filament
- Prosthetic arm was assembled with two soft muscles as the bicep and tricep
- Controlled by a pulley system connected to the muscles, enabling the forearm to be lifted when the bicep is actuated.

(a) (b) (c)

Figure 1: (a) Fabricated muscle (b) Inner support disk (c) Assembled arm

Results

- FEA with Ansys shows contraction along origami creases under negative pressure
- Load testing shows the muscle can actuate with up to 3kg, and hold 3kg of payload

Fig. 2: FEA on Ansys

Fig. 3: Load vs. Contraction ratio graph

Fig. 4: Muscle holding 3kg

Future Work

- Perform tensile testing on the TPU material
- Implement sensors for improved control
- Conduct fatigue test to determine the muscle's life cycle

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Acknowledgement

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AGI-powered Service Robot

As robotics and artificial general intelligence play increasingly prominent roles in human lives and routines, elderly people living alone or in nursing homes, as well as their caregivers, are groups that could benefit from those developments. The world's elderly population has grown to a number it has never been close to. In America alone, in 2022, there were 57.8 million adults aged 65 and older; by 2054, this number is projected to increase to 84 million. These aging populations will inevitably be challenged by their decaying mental and physical ability, and our project explores this burgeoning field by developing a service robot to assist them with daily living tasks. Our team designed a structure with six degrees of freedom and a gripper to resemble human hand motion, providing the robotic arm with a wide range of complex movement and helping acceptance into users' homes. The robot moves with omni-wheels, allowing it to traverse an intermediate surface and complex environment. To ensure the robot could interact with objects (e.g. water bottles or mugs) from most household tables, the height of the robot was designed to be 36.2 in. The base has a 21.5 in square footprint, ensuring its stability and mobility while moving through tight corners and spaces. An onboard LiDAR sensor detects walls and obstacles around the robot, allowing it to generate paths to navigate indoor environments. ROS is used to integrate the different motors and sensors utilized by the robot. Our project has explored possible solutions to the physical limitations (navigation, stability, object delivery, etc.) surrounding the widespread implementation of at-home service robots. Moving forward, the human-robot interaction between elderly people could be studied to further promote the implementation of at-home service robots, elevating the quality of life for one of our most vulnerable populations.

Project Supervisor Rui Li

Research Areas Data Science/AI/Robotics

NYU TANDON SCHOOL OF ENGINEERING

AGI-powered Service Robot

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Abstract

As robotics and artificial general intelligence play increasingly prominent roles in human lives and routines, elderly people living alone or in nursing homes who struggle with decaying abilities, as well as their caregivers, are groups that could benefit from those developments. Our project explores this field by developing a service robot to assist with daily living tasks.

Background

Elderly people are one of the most vulnerable groups in the population due to their decline in the ability to support themselves as they age. As a result, they end up requiring support with their daily routines such as retrieval of food and water, and medication. This often causes them to have to relocate to nursing homes with few caretakers across many patients. Else, they still may require around the clock care, or will simply struggle significantly with routine tasks. Robotics has been introduced to and becoming more prevalent in environments such as nursing homes due to their potential in assisting caretakers in performing these everyday tasks for patients [2]. This project studies the ability of robots to effectively increase the quality of life for both patients and their caretakers by developing a service robot that is aimed to explore navigation around users' environments and manipulation of objects as required by users.

Methodology

Computer-aided design (C.A.D.) and 3D printing have been used in order to digitally design parts before fabrication, as well as to produce lightweight parts with easily customizable measurements, which enables the robot's mechanisms to be altered to best accommodate users and their environments.



Figure 1: C.A.D. Model of Robotic Arm

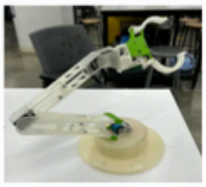


Figure 2: 3D Printed Prototype of Robotic Arm

Light detection and ranging (LiDAR) is used to map environments using laser pulses that detect distances between the LiDAR sensor on the robot and objects.
Computer vision utilizes artificial intelligence to detect and identify objects. This will be used by the robot to identify and interact with objects that have been included in daily tasks and special user requests. The robot operating system (R.O.S.) is used to integrate and connect all of the components of the system, enabling the robot to use its motors and sensors, as well as process sensor data in real-time, in order to effectively perform tasks and communicate with the user.

Further Discussion

This research will continue to optimize human-robot interaction in household environments. We have explored the various concerns of developing an effective at-home service robot, such as navigation of environments, stability, and assistive functionality. We will study the interactive aspect of integrating such robots into households; factors that impact their efficacy for users include communication and aesthetic design. Alongside assisting elderly people and caretakers with daily activities, the continued research of at-home service robots could promote independence in users. Patients of nursing homes have been shown to have higher rates of depression than their peers due to factors such as their environment, loss of independence, and loss of privacy [1]. By using a device that helps with daily tasks, elderly patients may become more independent, further elevating their quality of life. This research can also potentially be used to study other groups of patients who suffer from conditions that restrict their autonomy and quality of life.

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Applications of Traffic Simulation-Based AI Models in Predicting Emergency Vehicle Performance During Emergency Responses

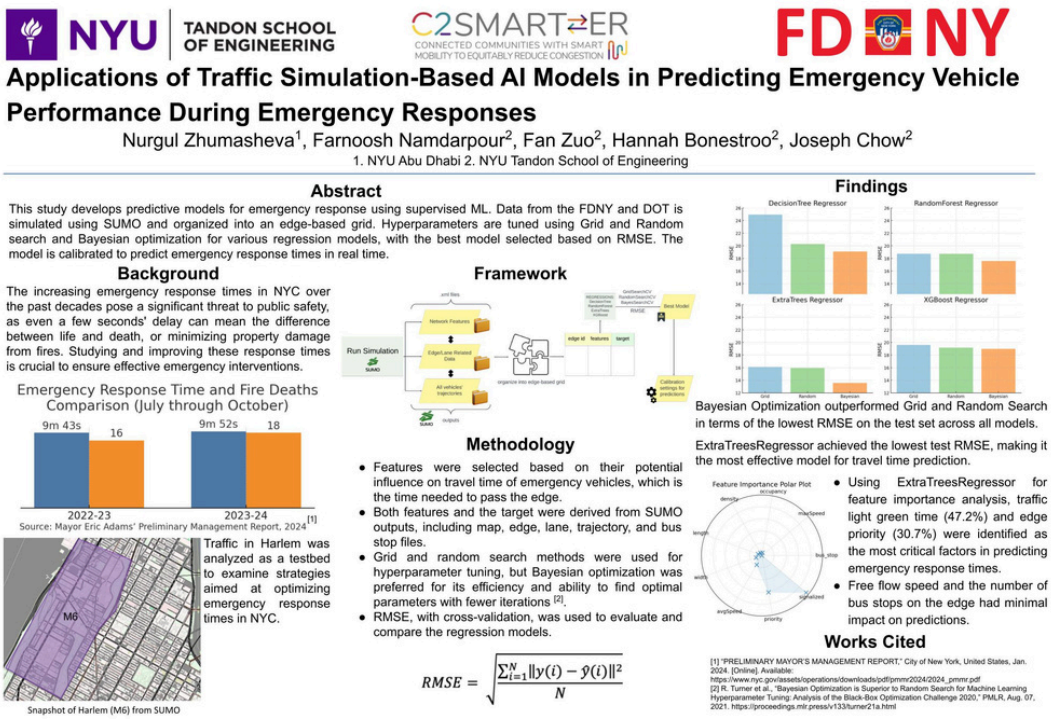
New York City's emergency response system faces increasing challenges, as evidenced by the rising emergency response times in recent years. Given that mere seconds can save lives or property from fire damage, optimizing emergency response times is crucial. Unlike Google Waze, which provides real-time traffic conditions for private vehicles, there is no software offering real-time traffic data for emergency vehicle routes in NYC. This research focuses on developing predictive models for emergency vehicle response using supervised machine learning. Leveraging data from the FDNY and DOT, traffic simulations are conducted using SUMO. The network features and simulation outputs are organized into an edge-based grid, which is then used to tune hyperparameters via Grid Search, Random Search, and Bayesian optimization for various regression models. The data is split into training and testing sets, and the most effective model is selected based on cross-validation results using Root Mean Squared Error (RMSE). The parameters of the model with the best performance in terms of low RMSE are calibrated, enabling the model to predict emergency response times based on real-time traffic conditions. This approach aims to significantly improve the efficiency and effectiveness of emergency response in urban environments.

Project Supervisor Joseph Chow

Research Areas Data Science/AI/Robotics



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Microtransit Revenue Management Strategy Design with an Agent-Based Behavioral Model

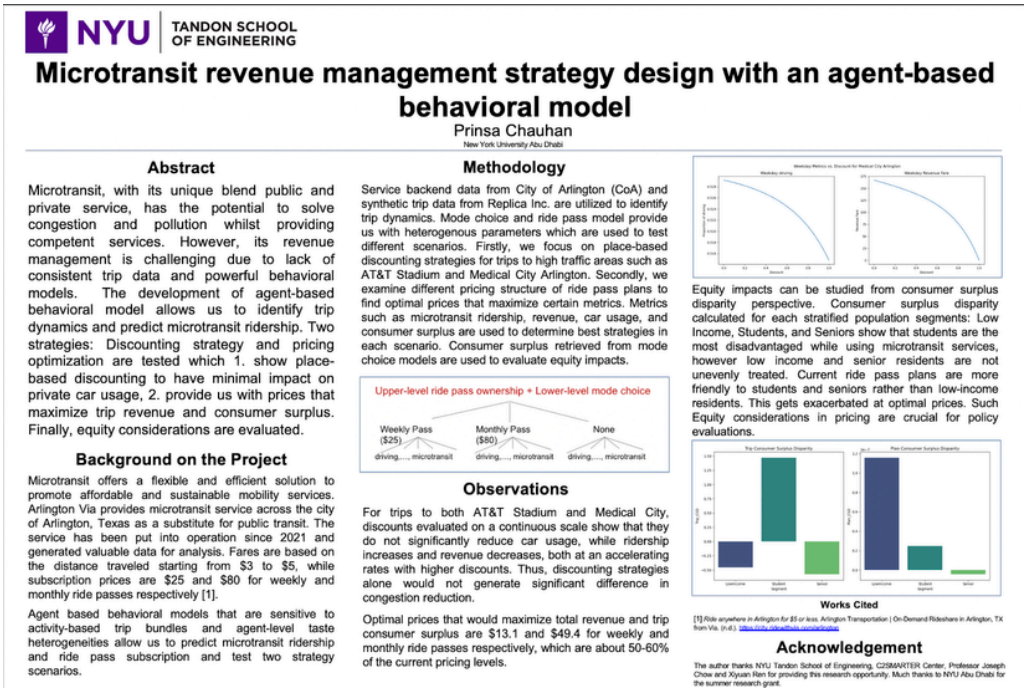
Microtransit offers a flexible and efficient solution to promote affordable and sustainable mobility services. However, its revenue management is usually challenging due to the lack of consistent trip data and powerful behavioral models. Arlington Via provides microtransit service across the city as a substitute for public transit. The service has been put into operation since 2021 and generated valuable data for analysis. This summer project aims to design revenue management strategies for Arlington Via using an agent-based behavioral model developed in an on-going project supported by the C2SMARTER Center. Service backend data from City of Arlington (CoA) and synthetic trip data from Replica Inc. are utilized to identify trip dynamics. A set of heterogeneous parameters estimated by the model are used to predict microtransit ridership and Ride Pass subscription. Two strategy scenarios are considered for pricing, revenue, and policy evaluations in this project. The first scenario focuses on place-based discounting strategies for trips to high-traffic areas like AT&T Stadium and Medical City Arlington. The second scenario examines different pricing for current ride pass plans, with weekly passes ranging from $15 to $35 (currently $25) and monthly passes from $60 to $ 0 (currently $80). The best strategy in each scenario is identified using metrics such as microtransit ridership, total revenue, number of subscribers, reduction of car usage, and trip consumer surplus. Finally, the equity impacts of these strategies are explored from a disparity perspective and an insufficiency perspective. Results indicate that discounts do not significantly reduce car usage, and ridership increases while revenue decreases at an accelerating rate with higher discounts. The optimal prices for maximizing trip revenue and consumer surplus are $13.1 for weekly passes and $49.4 for monthly passes. Equity analysis offers understanding of the impact of these strategies which can be used for redirection and policy evaluation for equitable transportation services. The results of this project could provide valuable insights for the intelligible and sustainable design of microtransit.

Project Supervisor Joseph Chow

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Microtransit revenue management strategy design with an agent-based behavioral model

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Abstract

Microtransit, with its unique blend public and private service, has the potential to solve congestion and pollution whilst providing competent services. However, its revenue management is challenging due to lack of consistent trip data and powerful behavioral models. The development of agent-based behavioral model allows us to identify trip dynamics and predict microtransit ridership. Two strategies: Discounting strategy and pricing optimization are tested which 1. show place-based discounting to have minimal impact on private car usage, 2. provide us with prices that maximize trip revenue and consumer surplus. Finally, equity considerations are evaluated.

Background on the Project

Microtransit offers a flexible and efficient solution to promote affordable and sustainable mobility services. Arlington Via provides microtransit service across the city of Arlington, Texas as a substitute for public transit. The service has been put into operation since 2021 and generated valuable data for analysis. Fares are based on the distance traveled starting from $3 to $5, while subscription prices are $25 and $80 for weekly and monthly ride passes respectively [1].

Agent based behavioral models that are sensitive to activity-based trip bundles and agent-level taste heterogeneities allow us to predict microtransit ridership and ride pass subscription and test two strategy scenarios.

Methodology

Service backend data from City of Arlington (CoA) and synthetic trip data from Replica Inc. are utilized to identify trip dynamics. Mode choice and ride pass model provide us with heterogenous parameters which are used to test different scenarios. Firstly, we focus on place-based discounting strategies for trips to high traffic areas such as AT&T Stadium and Medical City Arlington. Secondly, we examine different pricing structure of ride pass plans to find optimal prices that maximize certain metrics. Metrics such as microtransit ridership, revenue, car usage, and consumer surplus are used to determine best strategies in each scenario. Consumer surplus retrieved from mode choice models are used to evaluate equity impacts.

Upper-level ride pass ownership + Lower-level mode choice

Weekly Pass ($25) — driving, ..., microtransit
Monthly Pass ($80) — driving, ..., microtransit
None — driving, ..., microtransit

Observations

For trips to both AT&T Stadium and Medical City, discounts evaluated on a continuous scale show that they do not significantly reduce car usage, while ridership increases and revenue decreases, both at an accelerating rates with higher discounts. Thus, discounting strategies alone would not generate significant difference in congestion reduction.

Optimal prices that would maximize total revenue and trip consumer surplus are $13.1 and $49.4 for weekly and monthly ride passes respectively, which are about 50-60% of the current pricing levels.

Equity impacts can be studied from consumer surplus disparity perspective. Consumer surplus disparity calculated for each stratified population segments: Low Income, Students, and Seniors show that students are the most disadvantaged while using microtransit services, however low income and senior residents are not unevenly treated. Current ride pass plans are more friendly to students and seniors rather than low-income residents. This gets exacerbated at optimal prices. Such Equity considerations in pricing are crucial for policy evaluations.

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Acknowledgement

The author thanks NYU Tandon School of Engineering, C2SMARTER Center, Professor Joseph Chow and Xiyuan Ren for providing this research opportunity. Much thanks to NYU Abu Dhabi for the summer research grant.

Smart Textile Integration in Hand Orthoses: Enhancing Stroke Rehabilitation with Twisted and Coiled Polymer Actuators

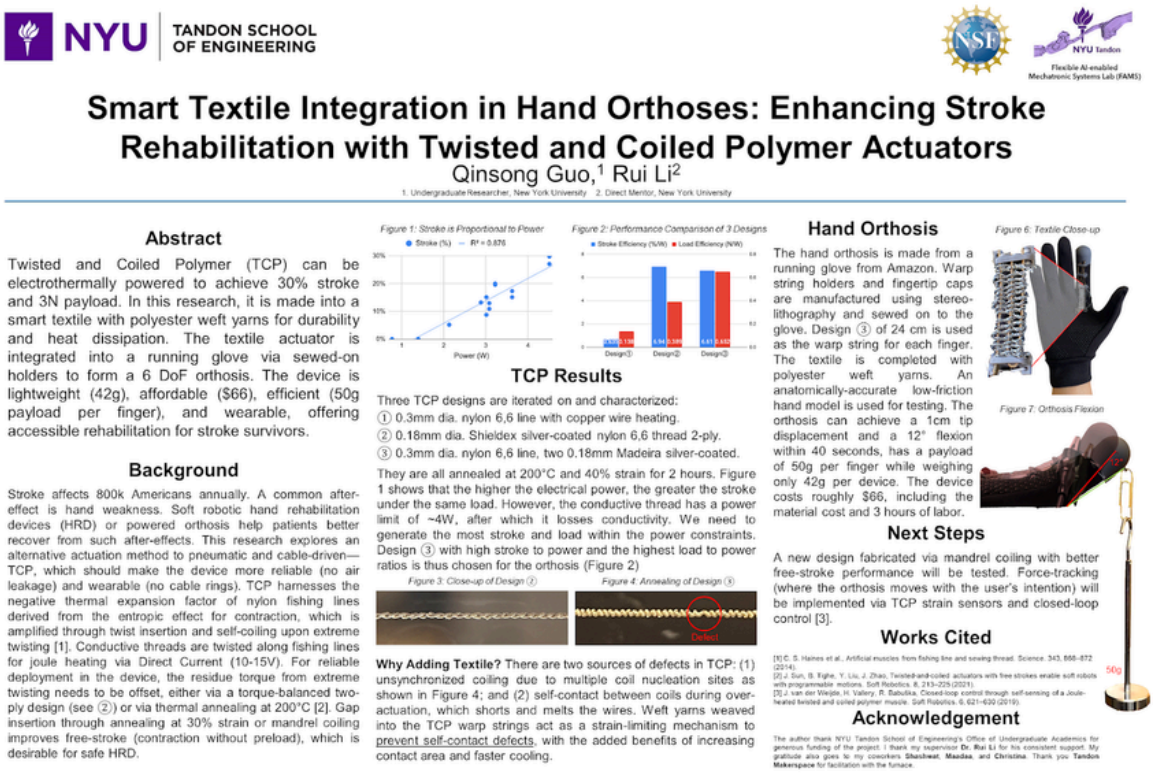
Wearable, powered exoskeletons that are soft and wearable are new tools that might help with rehabilitation by enabling people to walk farther and perform daily tasks. However, there is a lack of clinical adoption for soft robotic exoskeletons. The development of soft robotic exoskeletons has faced multiple challenges such as lack of purposely-built simulation model, fragile nature and limited selections of materials and non-linear pneumatic control. This project builds on top of past effort of fabricating a wearable exoskeleton devices for the upper limbs to enhance patients' mobility. There is an estimated of over 42 million people have some degrees of movement disorder. This devices would enable patients to regain daily activities such as picking and placing multiple objects. The system consists a wearable exoskeleton covers the arm and fingers with a power backpack. The results could be published in the venues of IEEE IROS/ICRA.

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NYU TANDON SCHOOL OF ENGINEERING

NYU Tandon Flexible AI-enabled Mechatronic Systems Lab (FAMS)

Smart Textile Integration in Hand Orthoses: Enhancing Stroke Rehabilitation with Twisted and Coiled Polymer Actuators

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Abstract

Twisted and Coiled Polymer (TCP) can be electrothermally powered to achieve 30% stroke and 3N payload. In this research, it is made into a smart textile with polyester weft yarns for durability and heat dissipation. The textile actuator is integrated into a running glove via sewed-on holders to form a 6 DoF orthosis. The device is lightweight (42g), affordable ($66), efficient (50g payload per finger), and wearable, offering accessible rehabilitation for stroke survivors.

Background

Stroke affects 800k Americans annually. A common after-effect is hand weakness. Soft robotic hand rehabilitation devices (HRD) or powered orthosis help patients better recover from such after-effects. This research explores an alternative actuation method to pneumatic and cable-driven—TCP, which should make the device more reliable (no air leakage) and wearable (no cable rings). TCP harnesses the negative thermal expansion factor of nylon fishing lines derived from the entropic effect for contraction, which is amplified through twist insertion and self-coiling upon extreme twisting [1]. Conductive threads are twisted along fishing lines for joule heating via Direct Current (10-15V). For reliable deployment in the device, the residue torque from extreme twisting needs to be offset, either via a torque-balanced two-ply design (see ②) or via thermal annealing at 200°C [2]. Gap insertion through annealing at 30% strain or mandrel coiling improves free-stroke (contraction without preload), which is desirable for safe HRD.

Figure 1: Stroke is Proportional to Power

Figure 2: Performance Comparison of 3 Designs

TCP Results

Three TCP designs are iterated on and characterized:
① 0.3mm dia. nylon 6,6 line with copper wire heating.
② 0.18mm dia. Shieldex silver-coated nylon 6,6 thread 2-ply.
③ 0.3mm dia. nylon 6,6 line, two 0.18mm Madeira silver-coated.

They are all annealed at 200°C and 40% strain for 2 hours. Figure 1 shows that the higher the electrical power, the greater the stroke under the same load. However, the conductive thread has a power limit of ~4W, after which it losses conductivity. We need to generate the most stroke and load within the power constraints. Design ③ with high stroke to power and the highest load to power ratios is thus chosen for the orthosis (Figure 2)

Figure 3: Close-up of Design ②

Figure 4: Annealing of Design ①

Why Adding Textile? There are two sources of defects in TCP: (1) unsynchronized coiling due to multiple coil nucleation sites as shown in Figure 4; and (2) self-contact between coils during over-actuation, which shorts and melts the wires. Weft yarns weaved into the TCP warp strings act as a strain-limiting mechanism to prevent self-contact defects, with the added benefits of increasing contact area and faster cooling.

Hand Orthosis

The hand orthosis is made from a running glove from Amazon. Warp string holders and fingertip caps are manufactured using stereo-lithography and sewed on to the glove. Design ③ of 24 cm is used as the warp string for each finger. The textile is completed with polyester weft yarns. An anatomically-accurate low-friction hand model is used for testing. The orthosis can achieve a 1cm tip displacement and a 12° flexion within 40 seconds, has a payload of 50g per finger while weighing only 42g per device. The device costs roughly $66, including the material cost and 3 hours of labor.

Figure 6: Textile Close-up

Figure 7: Orthosis Flexion

Next Steps

A new design fabricated via mandrel coiling with better free-stroke performance will be tested. Force-tracking (where the orthosis moves with the user's intention) will be implemented via TCP strain sensors and closed-loop control [3].

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The author thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. I thank my supervisor **Dr. Rui Li** for his consistent support. My gratitude also goes to my coworkers **Shashwat, Maadaa**, and **Christina**. Thank you **Tandon Makerspace** for facilitation with the furnace.

Robotic Manipulation of a Scaled Intermeshed Steel Connection

Intermeshed Steel Construction (ISC) is a new technique for column and beam connections that would eliminate field welding and reduce the time cost and frequency of bolting. This project aims to assemble these structures with an autonomous robotic arm. The complex and precise prototype simultaneously developing in Professor Laefer's NYU Urban Modeling group requires the robot to perform the assembly consistently with minuscule tolerance. Before the robot could precisely assemble this model, it requires mastering the mechanism at each place that pieces touched – connection areas. The approach is to develop models that feature individual connection areas. In this project, we have designed and fabricated two preliminary 3D models with Fusion360 and 3D printers. These two models include simplified versions of intermeshing teeth, shear plates fastened with M16 nuts and bolts, and connection plates between flanges. We then scripted Python code with Pinocchio to plan feasible methods of assembly in a 3D environment. This includes robotic motion and trajectory simulations. The team successfully designed and 3D printed two preliminary models and began virtual simulations. The next step will be to consider more complicated models working towards the scaled prototype from Professor Laefer's team and eventually an actual size model. Our work will directly aid future researchers in programming an algorithm to assemble more complex models.

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NYU TANDON SCHOOL OF ENGINEERING

MACHINES IN MOTION

Robotic Manipulation of a Scaled Intermeshed Steel Connection

Ruby Perkis[1] , Rachel Chen[1], Joaquim Ortiz De Haro[2], Advadesh Meduri[2], Ludovic Righetti[3]

1. NYU Undergraduate Summer Researchers 2. Mentors 3. Faculty Mentor

Abstract

Intermeshed Steel Construction (ISC) is a new technique for column and beam connections that would eliminate field welding and reduce the time cost and frequency of bolting [1, 2]. This project aims to assemble these structures with an autonomous robotic arm. The complex and precise prototype simultaneously developing in Professor Laefer's NYU Urban Modeling group requires the robot to perform the assembly consistently with minuscule tolerance. This requires mastering robotic assembly at all places pieces touched – connection areas. The approach is to develop simplified models that feature simplified connection areas. We have designed and fabricated two preliminary 3D models. We then scripted Python code with Pinocchio to plan robotic motion trajectory for assembly in a 3D environment. The next step will be to consider more complicated models working towards the scaled prototype from Professor Laefer's team and eventually an actual size model.

Methods

Figure 1: Methodology

We designed two preliminary 3D models replicating features of ISC steel frames (figures 3,4). The prototype for the beam-to-stub ISC has three main connection features: intermeshing end teeth on the flanges, a shear plate fastened with M16 nuts and bolts, and connection plates fastened by T-bolts, C Washers, and C Washer nuts. Simplified model 1 features the intermeshing end teeth and the shear plate. Simplified model 2 is inspired by the connection plates, focusing on the connections between the flanges. A removable external frame is necessary to support the bolts during assembly. We modeled and virtually assembled using Fusion 360 and 3D printed with Ultimaker 3 printers. We then scripted Python code to control assembly with the mechanical arm. We utilized the Pinocchio library in planning the trajectories of assembly.

Figure 2. ISC Beam-to-Stub Model by NYU Urban Modeling Group

Figure 3: Simplified Model 1. Left: CAD. Right: 3D Printed.

Figure 4: Simplified Model 2. Left: CAD. Right: 3D Printed.

Conclusions and Future Work

The team successfully designed and 3D printed two preliminary models and began virtual simulations. Our work will directly aid future researchers in programming an algorithm to assemble more complex models. Before uploading scripts to the robotic arm, there is more work to be done surrounding physical constraints. This will be done through MuJoCo. After finishing work with simplified models 1 and 2, we plan to expand to more complicated models, eventually manipulating NYU Urban Modeling Group's prototype (figure 2). Along with increasing complexity in models, we hope to increase trajectory efficiency.

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Acknowledgement

The authors thank:
NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.
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Professor Debra Laefer and Sreya Chakraborty for their collaboration and mentorship.

Advancing Tumor Detection: A Novel Approach Using Deep Learning

Challenges in current video-assisted thoracoscopic surgery and endoscopic surgery for tumor removal involve locating the tumor and determining the treatment necessary for the patient. Treatment plans and the efficiency of certain treatment methods, such as laser ablation, are determined by the size and depth of the tumor. This research project proposes a controllable, flexible robot equipped with a monocular camera that can assist in endoscopic procedures by detecting the size and relative depth of tumors. The camera will be used with the You Only Look Once (YOLO) objection detection and our custom size estimation algorithms to detect tumors and show their estimated size in real-time via a custom user interface, TAJ. The Robot Operating System (ROS), specifically ROS 2 Humble, will be used to integrate the YOLO and size estimation algorithms with the flexible robot in an Ubuntu environment. Currently, research is still being conducted, with the robot under construction, the YOLOv5 algorithm custom-trained on peer-labeled endoscopic surgery recordings, and the implementation of TAJ outputs in ROS 2 underway. As we refine the detection algorithm and integrate all of the components into the robot, we hope to eventually deploy our project in a real surgical environment, provided training and lab testing results show promising and safe use in such environments.

Project Supervisor Rui Li

Research Areas Data Science/AI/Robotics



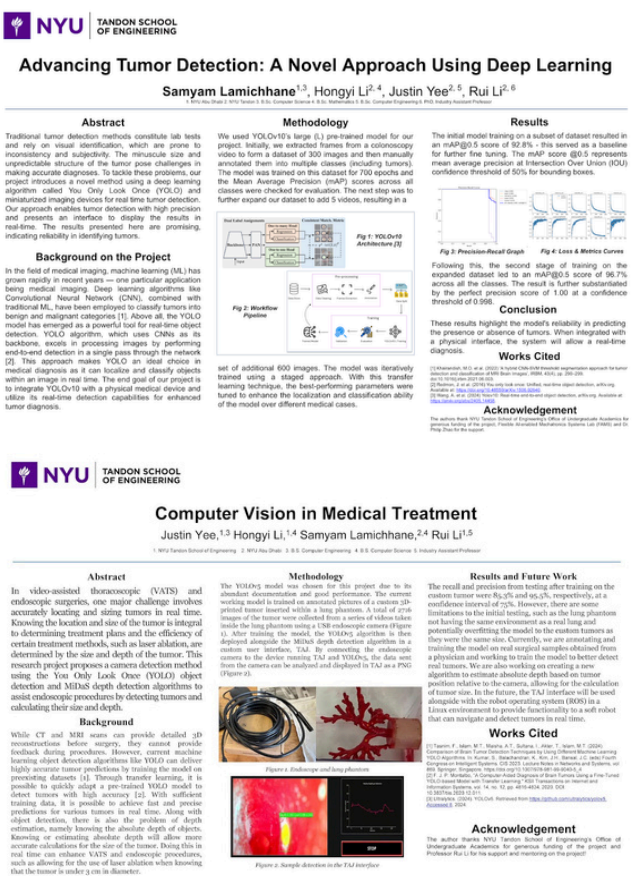
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NYU TANDON SCHOOL OF ENGINEERING

Advancing Tumor Detection: A Novel Approach Using Deep Learning

Samyam Lamichhane[1,3], Hongyi Li[2,4], Justin Yee[2,5], Rui Li[2,6]

Abstract

Traditional tumor detection methods constitute lab tests and rely on visual identification, which are prone to inconsistency and subjectivity. The minuscule size and unpredictable structure of the tumor pose challenges in making accurate diagnoses. To tackle these problems, our project introduces a novel method using a deep learning algorithm called You Only Look Once (YOLO) and miniaturized imaging devices for real time tumor detection. Our approach enables tumor detection with high precision and presents an interface to display the results in real-time. The results presented here are promising, indicating reliability in identifying tumors.

Background on the Project

In the field of medical imaging, machine learning (ML) has grown rapidly in recent years — one particular application being medical imaging. Deep learning algorithms like Convolutional Neural Network (CNN), combined with traditional ML, have been employed to classify tumors into benign and malignant categories [1]. Above all, the YOLO model has emerged as a powerful tool for real-time object detection. YOLO algorithm, which uses CNNs as its backbone, excels in processing images by performing end-to-end detection in a single pass through the network [2]. This approach makes YOLO an ideal choice in medical diagnosis as it can localize and classify objects within an image in real time. The end goal of our project is to integrate YOLOv10 with a physical medical device and utilize its real-time detection capabilities for enhanced tumor diagnosis.

Methodology

We used YOLOv10's large (L) pre-trained model for our project. Initially, we extracted frames from a colonoscopy video to form a dataset of 300 images and then manually annotated them into multiple classes (including tumors). The model was trained on this dataset for 700 epochs and the Mean Average Precision (mAP) scores across all classes were checked for evaluation. The next step was to further expand our dataset to add 5 videos, resulting in a set of additional 600 images. The model was iteratively trained using a staged approach. With this transfer learning technique, the best-performing parameters were tuned to enhance the localization and classification ability of the model over different medical cases.

Fig 1: YOLOv10 Architecture [3]

Fig 2: Workflow Pipeline

Results

The initial model training on a subset of dataset resulted in an mAP@0.5 score of 92.8% - this served as a baseline for further fine tuning. The mAP score @0.5 represents mean average precision at Intersection Over Union (IOU) confidence threshold of 50% for bounding boxes.

Fig 3: Precision-Recall Graph

Fig 4: Loss & Metrics Curves

Following this, the second stage of training on the expanded dataset led to an mAP@0.5 score of 96.7% across all the classes. The result is further substantiated by the perfect precision score of 1.00 at a confidence threshold of 0.998.

Conclusion

These results highlight the model's reliability in predicting the presence or absence of tumors. When integrated with a physical interface, the system will allow a real-time diagnosis.

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NYU TANDON SCHOOL OF ENGINEERING

Computer Vision in Medical Treatment

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Abstract

In video-assisted thoracoscopic (VATS) and endoscopic surgeries, one major challenge involves accurately locating and sizing tumors in real time. Knowing the location and size of the tumor is integral to determining treatment plans and the efficiency of certain treatment methods, such as laser ablation, are determined by the size and depth of the tumor. This research project proposes a camera detection method using the You Only Look Once (YOLO) object detection and MiDaS depth detection algorithms to assist endoscopic procedures by detecting tumors and calculating their size and depth.

Background

While CT and MRI scans can provide detailed 3D reconstructions before surgery, they cannot provide feedback during procedures. However, current machine learning object detection algorithms like YOLO can deliver highly accurate tumor predictions by training the model on preexisting datasets [4]. Through transfer learning, it is possible to quickly adapt a pre-trained YOLO model to detect tumors with high accuracy [2]. With sufficient training data, it is possible to achieve fast and precise predictions for various tumors in real time. Along with object detection, there is also the problem of depth estimation, namely knowing the absolute depth of objects. Knowing or estimating absolute depth will allow more accurate calculations for the size of the tumor. Doing this in real time can enhance VATS and endoscopic procedures, such as allowing for the use of laser ablation when knowing that the tumor is under 3 cm in diameter.

Methodology

The YOLOv5 model was chosen for this project due to its abundant documentation and good performance. The current working model is trained on annotated pictures of a custom 3D-printed tumor inserted within a lung phantom. A total of 3716 images of the tumor were collected from a series of videos taken inside the lung phantom using a USB endoscopic camera (Figure 1). After training the model, the YOLOv5 algorithm is then deployed alongside the MiDaS depth detection algorithm in a custom user interface, TAJ. By connecting the endoscopic camera to the device running TAJ and YOLOv5, the data sent from the camera can be analyzed and displayed in TAJ as a PNG (Figure 2).

Figure 1. Endoscope and lung phantom

Figure 2. Sample detection in the TAJ interface

Results and Future Work

The recall and precision from testing after training on the custom tumor were 85.3% and 95.5%, respectively, at a confidence interval of 75%. However, there are some limitations to the initial testing, such as the lung phantom not having the same environment as a real lung and potentially overfitting the model to the custom tumors as they were the same size. Currently, we are annotating and training the model on real surgical samples obtained from a physician and working to train the model to better detect real tumors. We are also working on creating a new algorithm to estimate absolute depth based on tumor position relative to the camera, allowing for the calculation of tumor size. In the future, the TAJ interface will be used alongside with the robot operating system (ROS) in a Linux environment to provide functionality to a soft robot that can navigate and detect tumors in real time.

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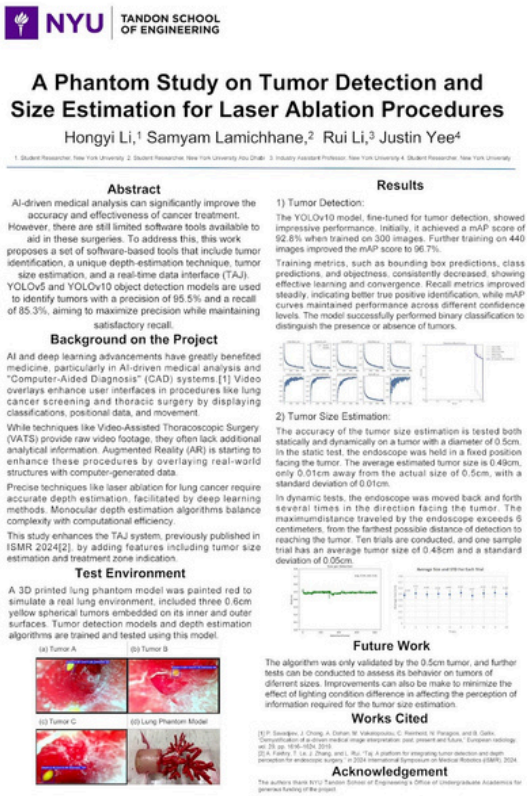
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NYU TANDON SCHOOL OF ENGINEERING

A Phantom Study on Tumor Detection and Size Estimation for Laser Ablation Procedures

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Abstract

AI-driven medical analysis can significantly improve the accuracy and effectiveness of cancer treatment. However, there are still limited software tools available to aid in these surgeries. To address this, this work proposes a set of software-based tools that include tumor identification, a unique depth-estimation technique, tumor size estimation, and a real-time data interface (TAJ). YOLOv5 and YOLOv10 object detection models are used to identify tumors with a precision of 95.5% and a recall of 85.3%, aiming to maximize precision while maintaining satisfactory recall.

Background on the Project

AI and deep learning advancements have greatly benefited medicine, particularly in AI-driven medical analysis and "Computer-Aided Diagnosis" (CAD) systems.[1] Video overlays enhance user interfaces in procedures like lung cancer screening and thoracic surgery by displaying classifications, positional data, and movement.

While techniques like Video-Assisted Thoracoscopic Surgery (VATS) provide raw video footage, they often lack additional analytical information. Augmented Reality (AR) is starting to enhance these procedures by overlaying real-world structures with computer-generated data.

Precise techniques like laser ablation for lung cancer require accurate depth estimation, facilitated by deep learning methods. Monocular depth estimation algorithms balance complexity with computational efficiency.

This study enhances the TAJ system, previously published in ISMR 2024[2], by adding features including tumor size estimation and treatment zone indication.

Test Environment

A 3D printed lung phantom model was painted red to simulate a real lung environment, included three 0.6cm yellow spherical tumors embedded on its inner and outer surfaces. Tumor detection models and depth estimation algorithms are trained and tested using this model.

(a) Tumor A (b) Tumor B (c) Tumor C (d) Lung Phantom Model

Results

1) Tumor Detection:

The YOLOv10 model, fine-tuned for tumor detection, showed impressive performance. Initially, it achieved a mAP score of 92.8% when trained on 300 images. Further training on 440 images improved the mAP score to 96.7%.

Training metrics, such as bounding box predictions, class predictions, and objectness, consistently decreased, showing effective learning and convergence. Recall metrics improved steadily, indicating better true positive identification, while mAP curves maintained performance across different confidence levels. The model successfully performed binary classification to distinguish the presence or absence of tumors.

2) Tumor Size Estimation:

The accuracy of the tumor size estimation is tested both statically and dynamically on a tumor with a diameter of 0.5cm. In the static test, the endoscope was held in a fixed position facing the tumor. The average estimated tumor size is 0.49cm, only 0.01cm away from the actual size of 0.5cm, with a standard deviation of 0.01cm.

In dynamic tests, the endoscope was moved back and forth several times in the direction facing the tumor. The maximum distance traveled by the endoscope exceeds 5 centimeters, from the farthest possible distance of detection to reaching the tumor. Ten trials are conducted, and one sample trial has an average tumor size of 0.48cm and a standard deviation of 0.05cm.

Future Work

The algorithm was only validated by the 0.5cm tumor, and further tests can be conducted to assess its behavior on tumors of different sizes. Improvements can also be make to minimize the effect of lighting condition difference in affecting the perception of information required for the tumor size estimation.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Impact of EMS Station Locations on Emergency Vehicle Response Times

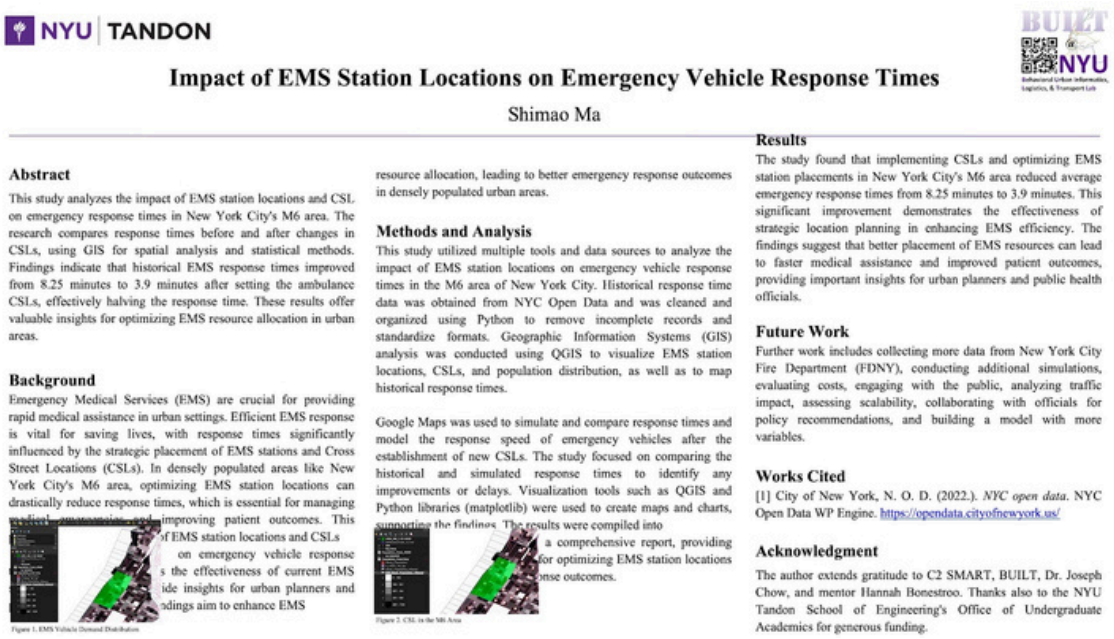
This study examines the impact of Emergency Medical Services (EMS) station locations and ambulance Cross Street Locations (CSL) on the response times of emergency vehicles in the M6 area of New York City. EMS is critical in urban health systems by providing rapid medical assistance during emergencies. The efficiency of EMS response is often influenced by the strategic placement of EMS stations and the locations of incidents. This research aims to analyze and compare response times before and after changes in CSLs and evaluate the effectiveness of current EMS station locations. The study identifies key factors affecting EMS efficiency by using historical data on EMS incidents and response times, geographic information systems (GIS) for spatial analysis, and statistical methods for comparing response durations. The results of this study show that historical EMS response times in the M6 area were 8.25 minutes, which improved to 3.33 minutes after setting the ambulance CSLs, making the EMS reaction time 2.5 times faster. These findings provide valuable insights for urban planners and public health officials to enhance the allocation of EMS resources, ultimately contributing to better emergency response outcomes in densely populated urban areas.

Project Supervisor Joseph Chow

Research Areas Data Science/AI/Robotics



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Impact of EMS Station Locations on Emergency Vehicle Response Times

Shimao Ma

Abstract

This study analyzes the impact of EMS station locations and CSL on emergency response times in New York City's M6 area. The research compares response times before and after changes in CSLs, using GIS for spatial analysis and statistical methods. Findings indicate that historical EMS response times improved from 8.25 minutes to 3.9 minutes after setting the ambulance CSLs, effectively halving the response time. These results offer valuable insights for optimizing EMS resource allocation in urban areas.

Background

Emergency Medical Services (EMS) are crucial for providing rapid medical assistance in urban settings. Efficient EMS response is vital for saving lives, with response times significantly influenced by the strategic placement of EMS stations and Cross Street Locations (CSLs). In densely populated areas like New York City's M6 area, optimizing EMS station locations can drastically reduce response times, which is essential for managing

improving patient outcomes. This

of EMS station locations and CSLs

on emergency vehicle response

s the effectiveness of current EMS

ide insights for urban planners and

ndings aim to enhance EMS

resource allocation, leading to better emergency response outcomes in densely populated urban areas.

Methods and Analysis

This study utilized multiple tools and data sources to analyze the impact of EMS station locations on emergency vehicle response times in the M6 area of New York City. Historical response time data was obtained from NYC Open Data and was cleaned and organized using Python to remove incomplete records and standardize formats. Geographic Information Systems (GIS) analysis was conducted using QGIS to visualize EMS station locations, CSLs, and population distribution, as well as to map historical response times.

Google Maps was used to simulate and compare response times and model the response speed of emergency vehicles after the establishment of new CSLs. The study focused on comparing the historical and simulated response times to identify any improvements or delays. Visualization tools such as QGIS and Python libraries (matplotlib) were used to create maps and charts, supporting the findings. The results were compiled into

a comprehensive report, providing

for optimizing EMS station locations

nse outcomes.

Results

The study found that implementing CSLs and optimizing EMS station placements in New York City's M6 area reduced average emergency response times from 8.25 minutes to 3.9 minutes. This significant improvement demonstrates the effectiveness of strategic location planning in enhancing EMS efficiency. The findings suggest that better placement of EMS resources can lead to faster medical assistance and improved patient outcomes, providing important insights for urban planners and public health officials.

Future Work

Further work includes collecting more data from New York City Fire Department (FDNY), conducting additional simulations, evaluating costs, engaging with the public, analyzing traffic impact, assessing scalability, collaborating with officials for policy recommendations, and building a model with more variables.

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Building AI Model to Perform the Finite Element Method

The goal of this project was to train an AI language model to tutor students to solve problems using the Finite Element Method (FEM). FEM is a method for solving problems characterized by differential equations by instead discretizing the problem into a number of “elements,” which can be handled algebraically. With access to help from an instructor inherently limited to working hours, the advent of widely available AI technology, such as ChatGPT, provides an opportunity for students to get immediate answers and enhance individualized learning. The initial phase of the research involved identifying the elements required to build image-to-text models. Using ChatGPT as the primary AI model for testing, it was trained to recognize elements, nodes, and supports and identify the boundary conditions to solve for the unknown parameters. A series of FEM problems involving spring and bar elements ranging from simple to complex were used as the training dataset. Despite infrequent inaccuracies in its image detection, ChatGPT discerned and computed the unknowns once prompted with an image. With additional fine-tuning and the use of the Application Programming Interface (API) of ChatGPT, the image-to-text model can be optimized to more accurately solve FEM problems. This entails enlarging the dataset or developing alternative models for detecting written problems or diagrams. In addition to FEM, the model could be trained to examine and correctly solve other challenging problems. In this way, a versatile learning environment can be established to aid students in different subject areas.

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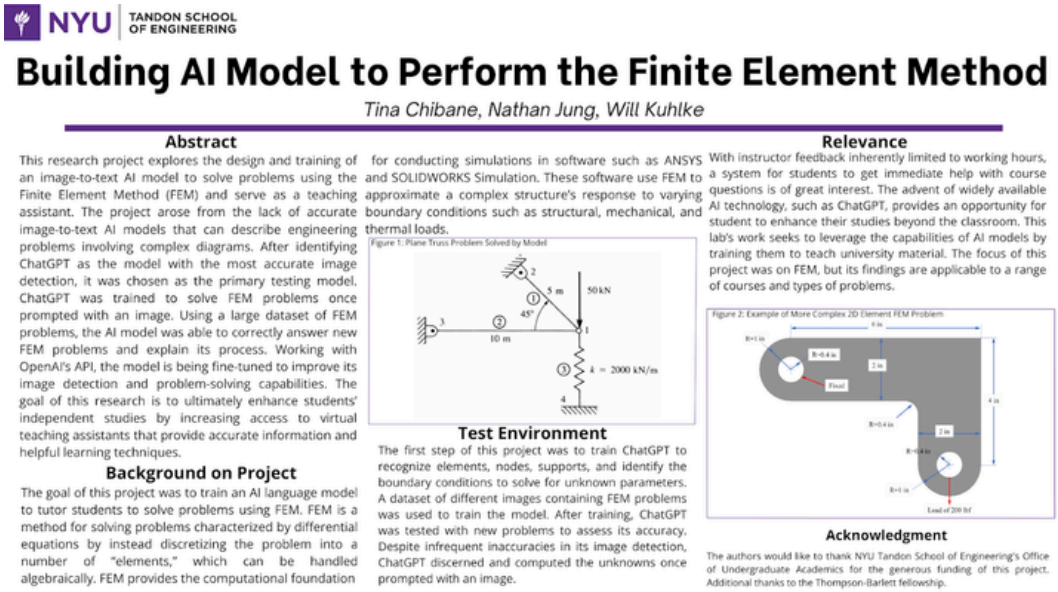
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NYU TANDON SCHOOL OF ENGINEERING

Building AI Model to Perform the Finite Element Method

Tina Chibane, Nathan Jung, Will Kuhlke

Abstract

This research project explores the design and training of an image-to-text AI model to solve problems using the Finite Element Method (FEM) and serve as a teaching assistant. The project arose from the lack of accurate image-to-text AI models that can describe engineering problems involving complex diagrams. After identifying ChatGPT as the model with the most accurate image detection, it was chosen as the primary testing model. ChatGPT was trained to solve FEM problems once prompted with an image. Using a large dataset of FEM problems, the AI model was able to correctly answer new FEM problems and explain its process. Working with OpenAI's API, the model is being fine-tuned to improve its image detection and problem-solving capabilities. The goal of this research is to ultimately enhance students' independent studies by increasing access to virtual teaching assistants that provide accurate information and helpful learning techniques.

Background on Project

The goal of this project was to train an AI language model to tutor students to solve problems using FEM. FEM is a method for solving problems characterized by differential equations by instead discretizing the problem into a number of "elements," which can be handled algebraically. FEM provides the computational foundation for conducting simulations in software such as ANSYS and SOLIDWORKS Simulation. These software use FEM to approximate a complex structure's response to varying boundary conditions such as structural, mechanical, and thermal loads.

Figure 1: Plane Truss Problem Solved by Model

Test Environment

The first step of this project was to train ChatGPT to recognize elements, nodes, supports, and identify the boundary conditions to solve for unknown parameters. A dataset of different images containing FEM problems was used to train the model. After training, ChatGPT was tested with new problems to assess its accuracy. Despite infrequent inaccuracies in its image detection, ChatGPT discerned and computed the unknowns once prompted with an image.

Relevance

With instructor feedback inherently limited to working hours, a system for students to get immediate help with course questions is of great interest. The advent of widely available AI technology, such as ChatGPT, provides an opportunity for student to enhance their studies beyond the classroom. This lab's work seeks to leverage the capabilities of AI models by training them to teach university material. The focus of this project was on FEM, but its findings are applicable to a range of courses and types of problems.

Figure 2: Example of More Complex 2D Element FEM Problem

Acknowledgment

The authors would like to thank NYU Tandon School of Engineering's Office of Undergraduate Academics for the generous funding of this project. Additional thanks to the Thompson-Barlett fellowship.

Co-VisiON: Co-Visibility ReasONing on Sparce Image Sets of Indoor Scenes

Humans possess amazing spatial reasoning abilities to analyze the co-visibility, i.e., the sharing of field-of-view, of a few images that are sparsely distributed in a complex scene. The large difference and the partial observability in those sparse views pose significant challenges to existing 3D vision techniques for pairwise image or feature-matching. A holistic approach that analyzes the entire set of images is essential for progress in 3D vision, embodied intelligence, and robotics. Thus, we propose the Co-Visibility reasONing Co-VisiON) task and curate an open-source dataset to facilitate the study of this problem. We develop an automated method to sample sparse image sets and their co-visibilities from photorealistic indoor simulation environments, allowing us to quickly generate a large-scale dataset from Gibson and HM3D environments. Additionally, we cross-validate the labeling of our dataset and test the trained model on our manually annotated co-visibilities, both on the generated and real-world sets. To solve this task, we benchmark various baselines on this dataset, including feature matching, visual place recognition (VPR), supervised or contrastive learning, and Large Vison Language Models (VLMs), among others.

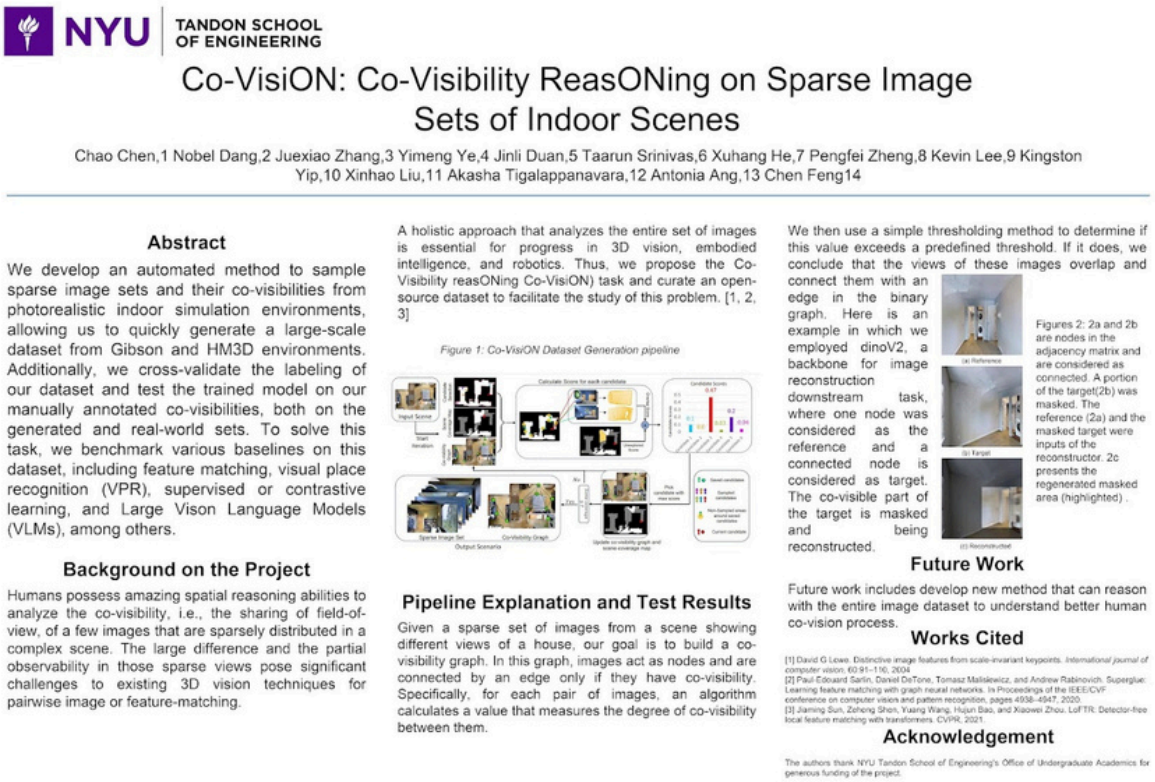
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NYU TANDON SCHOOL OF ENGINEERING

Co-VisiON: Co-Visibility ReasONing on Sparse Image Sets of Indoor Scenes

Chao Chen,1 Nobel Dang,2 Juexiao Zhang,3 Yimeng Ye,4 Jinli Duan,5 Taarun Srinivas,6 Xuhang He,7 Pengfei Zheng,8 Kevin Lee,9 Kingston Yip,10 Xinhao Liu,11 Akasha Tigalappanavara,12 Antonia Ang,13 Chen Feng14

Abstract

We develop an automated method to sample sparse image sets and their co-visibilities from photorealistic indoor simulation environments, allowing us to quickly generate a large-scale dataset from Gibson and HM3D environments. Additionally, we cross-validate the labeling of our dataset and test the trained model on our manually annotated co-visibilities, both on the generated and real-world sets. To solve this task, we benchmark various baselines on this dataset, including feature matching, visual place recognition (VPR), supervised or contrastive learning, and Large Vison Language Models (VLMs), among others.

Background on the Project

Humans possess amazing spatial reasoning abilities to analyze the co-visibility, i.e., the sharing of field-of-view, of a few images that are sparsely distributed in a complex scene. The large difference and the partial observability in those sparse views pose significant challenges to existing 3D vision techniques for pairwise image or feature-matching.

A holistic approach that analyzes the entire set of images is essential for progress in 3D vision, embodied intelligence, and robotics. Thus, we propose the Co-Visibility reasONing Co-VisiON) task and curate an open-source dataset to facilitate the study of this problem. [1, 2, 3]

Figure 1: Co-VisiON Dataset Generation pipeline

Pipeline Explanation and Test Results

Given a sparse set of images from a scene showing different views of a house, our goal is to build a co-visibility graph. In this graph, images act as nodes and are connected by an edge only if they have co-visibility. Specifically, for each pair of images, an algorithm calculates a value that measures the degree of co-visibility between them.

We then use a simple thresholding method to determine if this value exceeds a predefined threshold. If it does, we conclude that the views of these images overlap and connect them with an edge in the binary graph. Here is an example in which we employed dinoV2, a backbone for image reconstruction downstream task, where one node was considered as the reference and a connected node is considered as target. The co-visible part of the target is masked and being reconstructed.

Figures 2: 2a and 2b are nodes in the adjacency matrix and are considered as connected. A portion of the target(2b) was masked. The reference (2a) and the masked target were inputs of the reconstructor. 2c presents the regenerated masked area (highlighted) .

Future Work

Future work includes develop new method that can reason with the entire image dataset to understand better human co-vision process.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Improved Approximate Nearest Neighbor Algorithms for High Dimensions

Appoximate Nearest Neighbor Search (ANNS) is a problem that aims to approximate the data points closest to a given query in high dimensional space. These data points may originate from other formats, like images and documents, that are mapped to high dimensional vectors, making ANNS useful in contexts such as recommendation systems and deep learning. By selecting approximate closest points, ANNS algorithms unlock many techniques that trade accuracy for faster search time. One popular technique is HNSW, in which a multi-level sparse graph is constructed and traversed towards an input query. While this approach quickly converges to the query and limits the number of costly distance calculations performed, the latter can be optimized further. One focus of our work was to reimplement and evaluate GraSP, an algorithm that learns the importance of edges in a graph and prunes unimportant edges to reduce the number of distance calculations during search time. We compared it to a simpler point system that ranks edges based on how frequently they were traversed versus how frequently their distances were calculated. We also experimented with alternative termination methods and upper layer beam searches to improve search quality per distance calculation performed. We implemented all algorithms in C++ and benchmarked their recall versus number of search distance calculations on the SIFT1M, Deep1M, and GIST1M datasets. Preliminary results have shown that HNSW with cost-benefit pruning outperforms basic HNSW on SIFT1M and Deep1M, and that distance-based termination boosts performance on Deep1M. Our work will hopefully propel the ANNS problem forward by inspiring others to question the assumptions made by the HNSW algorithm to optimize it further.

Project Supervisor Torsten Suel

Research Areas Data Science/AI/Robotics

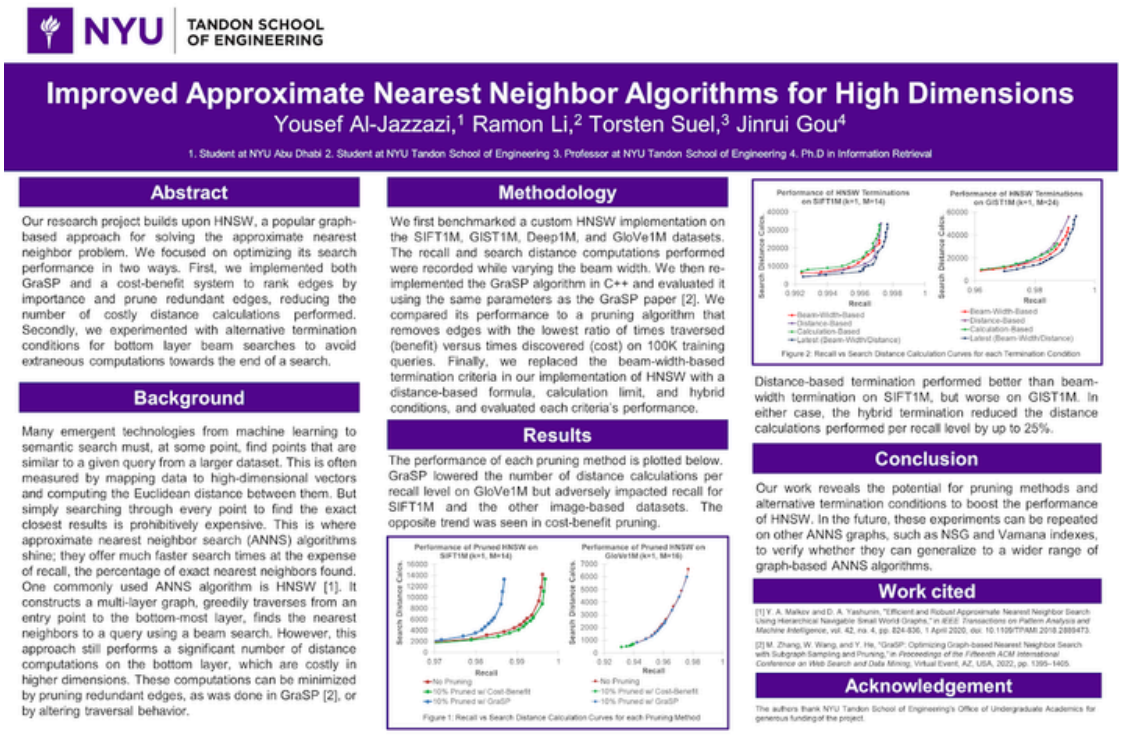
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NYU TANDON SCHOOL OF ENGINEERING

Improved Approximate Nearest Neighbor Algorithms for High Dimensions

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Abstract

Our research project builds upon HNSW, a popular graph-based approach for solving the approximate nearest neighbor problem. We focused on optimizing its search performance in two ways. First, we implemented both GraSP and a cost-benefit system to rank edges by importance and prune redundant edges, reducing the number of costly distance calculations performed. Secondly, we experimented with alternative termination conditions for bottom layer beam searches to avoid extraneous computations towards the end of a search.

Background

Many emergent technologies from machine learning to semantic search must, at some point, find points that are similar to a given query from a larger dataset. This is often measured by mapping data to high-dimensional vectors and computing the Euclidean distance between them. But simply searching through every point to find the exact closest results is prohibitively expensive. This is where approximate nearest neighbor search (ANNS) algorithms shine; they offer much faster search times at the expense of recall, the percentage of exact nearest neighbors found. One commonly used ANNS algorithm is HNSW [1]. It constructs a multi-layer graph, greedily traverses from an entry point to the bottom-most layer, finds the nearest neighbors to a query using a beam search. However, this approach still performs a significant number of distance computations on the bottom layer, which are costly in higher dimensions. These computations can be minimized by pruning redundant edges, as was done in GraSP [2], or by altering traversal behavior.

Methodology

We first benchmarked a custom HNSW implementation on the SIFT1M, GIST1M, Deep1M, and GloVe1M datasets. The recall and search distance computations performed were recorded while varying the beam width. We then re-implemented the GraSP algorithm in C++ and evaluated it using the same parameters as the GraSP paper [2]. We compared its performance to a pruning algorithm that removes edges with the lowest ratio of times traversed (benefit) versus times discovered (cost) on 100K training queries. Finally, we replaced the beam-width-based termination criteria in our implementation of HNSW with a distance-based formula, calculation limit, and hybrid conditions, and evaluated each criteria's performance.

Results

The performance of each pruning method is plotted below. GraSP lowered the number of distance calculations per recall level on GloVe1M but adversely impacted recall for SIFT1M and the other image-based datasets. The opposite trend was seen in cost-benefit pruning.

Figure 1: Recall vs Search Distance Calculation Curves for each Pruning Method

Figure 2: Recall vs Search Distance Calculation Curves for each Termination Condition

Distance-based termination performed better than beam-width termination on SIFT1M, but worse on GIST1M. In either case, the hybrid termination reduced the distance calculations performed per recall level by up to 25%.

Conclusion

Our work reveals the potential for pruning methods and alternative termination conditions to boost the performance of HNSW. In the future, these experiments can be repeated on other ANNS graphs, such as NSG and Vamana indexes, to verify whether they can generalize to a wider range of graph-based ANNS algorithms.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Evaluating Seed Set Impact on the LADR Algorithm: A Study on Efficiency and Performance

The Latent and Direct Retrieval (LADR) algorithm, a hybrid retrieval approach that combines latent semantic indexing with direct term matching, has demonstrated significant potential in improving retrieval quality across various contexts. This study aims to investigate the impact of different seed sets on the performance of the LADR algorithm, focusing on both its effectiveness and efficiency. We address three primary research questions: First, we assess the impact of seeds obtained from learned sparse models—such as deepimpact, splade, docT5query, and unicoil—on retrieval quality. Second, we examine the robustness of LADR's retrieval quality when employing seeds generated through aggressive early termination techniques for BM25, deepimpact, splade, and seeds derived from scaled-down sampled collections. Third, we analyze the trade-offs between efficiency and effectiveness resulting from these different seed choices. Our findings indicate that seeds from learned sparse models substantially enhance retrieval quality, while early termination techniques ensure robustness. However, a careful balance between efficiency and effectiveness is essential. These insights contribute to optimizing the LADR algorithm for various retrieval scenarios and provide a framework for future research and applications.

Research Areas Data Science/AI/Robotics

Project Supervisor Torsten Suel

Research Staff Jinrui Gou



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NYU TANDON SCHOOL OF ENGINEERING

Evaluating Seed Set Impact on the LADR Algorithm: A Study on Efficiency and Performance

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Abstract

The Latent and Direct Retrieval (LADR) algorithm, which combines latent semantic indexing with direct term matching, improves retrieval quality. This study evaluates the impact of different seed sets on LADR's performance, focusing on seeds from learned sparse models and early termination techniques. Our findings show that learned sparse models enhance retrieval quality, while early termination ensures robustness, highlighting the need for a balance between efficiency and effectiveness. These insights optimize LADR for various scenarios and guide future research.

Background on the Project

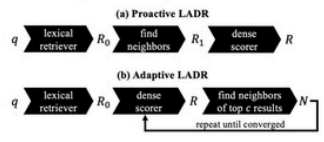
Search engine technology aims to improve the accuracy and efficiency of information retrieval. Traditional methods, focusing on direct term matching, often miss the nuances of natural language. The Latent and Direct Retrieval (LADR) algorithm combines latent semantic indexing with direct term matching to enhance retrieval quality.

This study optimizes LADR by examining different seed sets:

1. **Learned Sparse Models**: Seeds from models like DeepImpact[2], DeeperImpact[3], Splade[4], docT5query[5], and TILDE[6].
2. **Early Termination Techniques**: Seeds generated through techniques for BM25 and DeepImpact.
3. **Efficiency vs. Effectiveness**: Analyzing trade-offs in performance.

Findings show that seeds from learned models improve retrieval quality, while early termination ensures robustness. Balancing efficiency and effectiveness is crucial for optimizing LADR for various scenarios. These insights guide future research and applications in search engine technology.

Figure 1: LADR Algorithm



Methodology

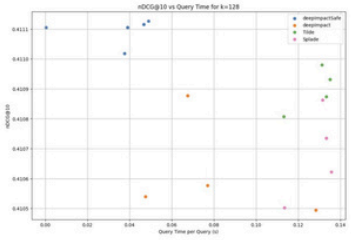
To evaluate the algorithm, experiments were setup where the lexical retriever were replaced with precomputed seeds of different learned models.

We utilized datasets from MSMARCO-PASSAGE, mainly TREC-2019, TREC-2020, Dev/2 and Dev/small.

The experiments measured key metrics such as RR@10, RR@20, RR@50, nDCG, nDCG@10, R@10, R@20, R@50, R@100, R@200, R@400, R@1000, MAP, and NumRelRet. Early termination LADR was used, meaning the algorithm was stopped before full convergence was achieved. Early Termination allowed for the assessment of initial performance and efficiency. As shown in Figure 2, the findings indicated that DeepImpact seeds could achieve SPLADE and TILDE performance in less query time, although SPLADE seeds required more time and showed potential for higher performance with additional iterations.

Data analysis focused on the trade-offs between efficiency and effectiveness. The results highlighted that DeepImpact seeds fit the LADR algorithm better under limited iteration settings, but SPLADE seeds could surpass them given enough iterations. This observation suggests that while DeepImpact offers quicker convergence, SPLADE may provide better long-term performance

Figure 2: nDCG@10 vs Query Time per query for different Models



Results

The experiments demonstrated that different seed models significantly impact the performance and efficiency of the LADR algorithm. DeepImpact seeds showed promise in terms of quick convergence and efficiency, achieving comparable performance to SPLADE and TILDE in less time. However, SPLADE seeds, although slower, have the potential for significant performance improvement with more iterations, indicating a need for a balance between efficiency and effectiveness.

Conclusion

This study provides valuable insights into optimizing the LADR algorithm for various retrieval scenarios. The findings suggest that while DeepImpact seeds are more efficient in reaching convergence quickly, SPLADE seeds may offer better performance with sufficient iterations. These insights can guide future research and practical applications in enhancing search engine technologies.

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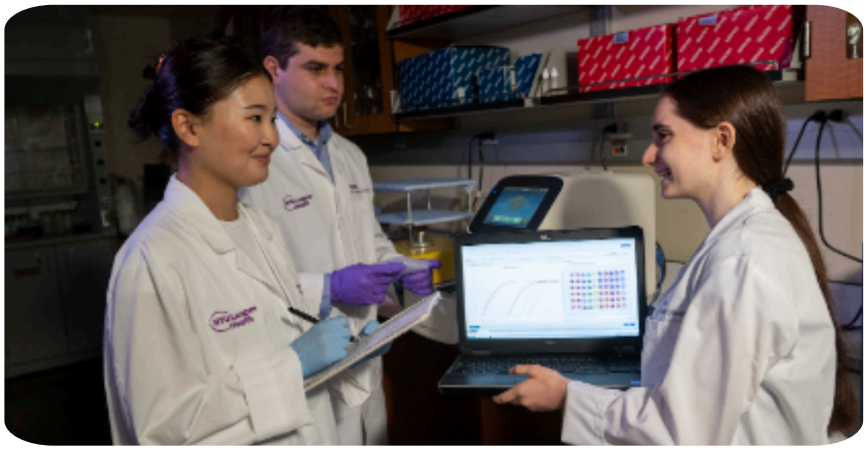
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Acknowledgement

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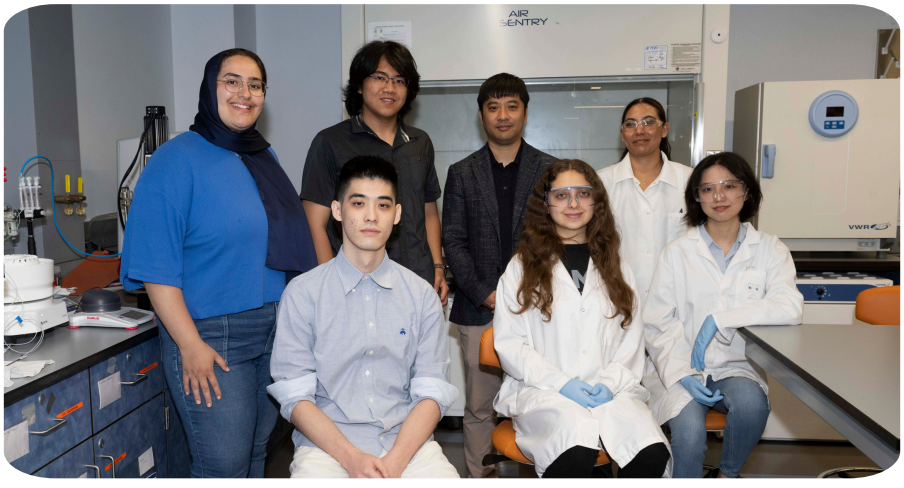
Dana Kagan (left) and Gulsim Azirakhmet (right)
Analyzing the results of quantitative real time PCR analysis to determine the gene expression of macrophages after treatment with an anti-inflammatory peptide



Anisha Ganesh
Anisha is preparing cells for CRISPR transformation



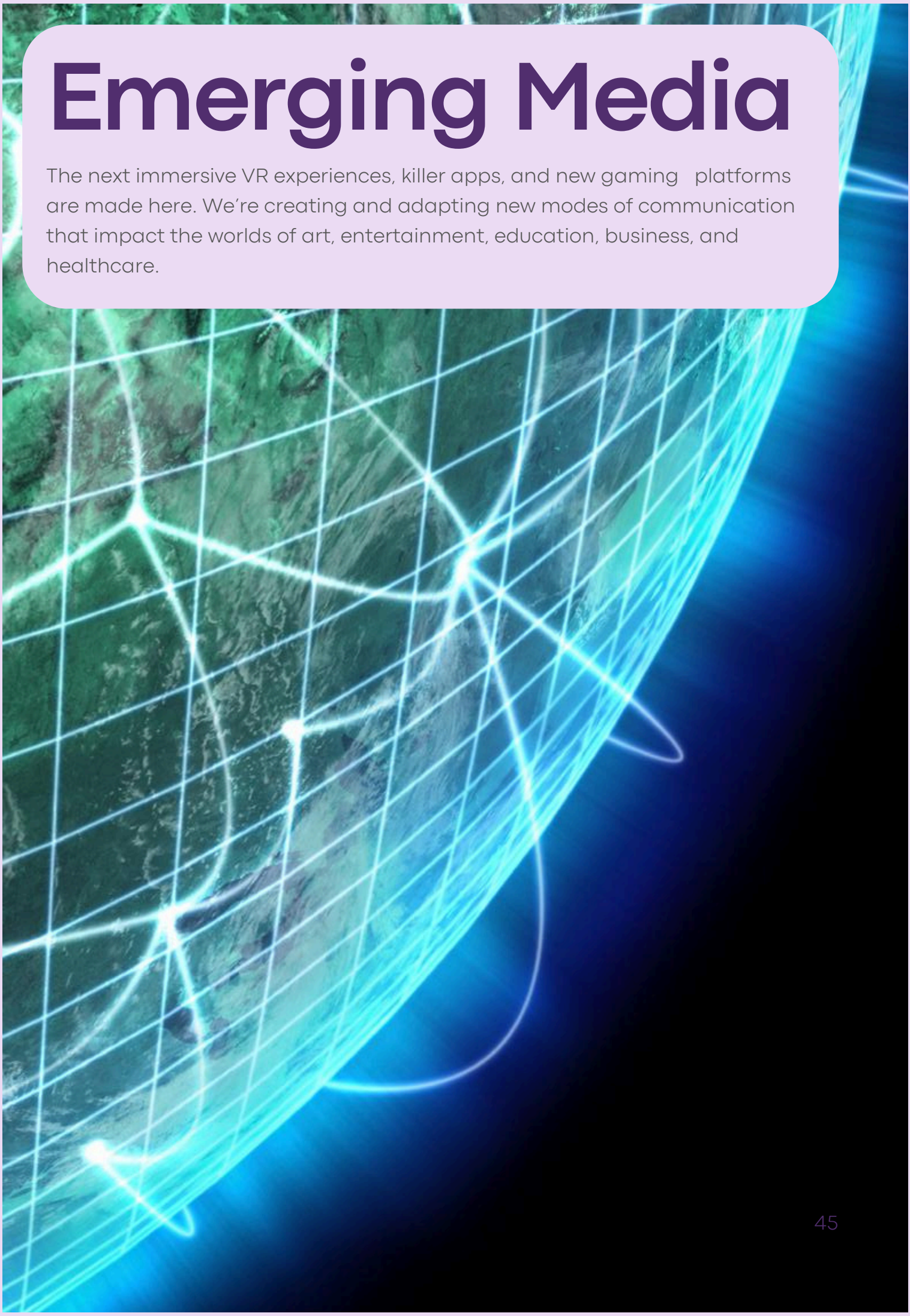
Nayan Sarode (Left), Kevin Yang (Middle), and John Abanes (Right)
The team is presenting the mobile data collection systems used to map out 3D Environments using 360 images and pointcloud data.



Summer Research team, Angie, Terry, Prof. Wang, Jessica, Lucas, Dania and Yaxin.
Prof. Wang's Team in summer 2024

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.



Exploring Emerging Media Techniques: Evaluating Volumetric Capture, Motion Capture, and ICVFX in Experimental Production

Volumetric capture, motion capture, and virtual production are three emerging media techniques revolutionizing the media and entertainment industry. Volumetric capture captures a three-dimensional space or performance, allowing the data to be viewed on flat screens, 3D displays, and VR goggles. Motion capture, using Motive software and OptiTrack cameras, tracks and captures the motion of retroreflective markers attached to people and objects, delivering real-time motion data with unparalleled accuracy. Virtual production utilizes a real-time game engine like Unreal Engine, to display virtual environments on massive LED screens, enabling real-world actors to interact with these environments seamlessly. Our research project at NYU Tandon @ The Yard aims to compare these three techniques and evaluate their effectiveness against traditional media methods through the production of an experimental fashion film. The results showcase the three completed demos, highlighting the distinct visual and practical outcomes of each technique. By documenting the production process, we provide insights into the strengths, limitations, and potential applications of volumetric capture, motion capture, and virtual production in various media and entertainment contexts. This study deepens our understanding of these innovative technologies and offer insights for future the endeavors in the emerging media field.

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Research Areas Emerging Media



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NYU TANDON SCHOOL OF ENGINEERING

Exploring Emerging Media Techniques: Evaluating Volumetric Capture, Motion Capture, and ICVFX in Experimental Production

Aakarsh Singh, Huiwei Wen

Abstract

Volumetric capture, motion capture, and virtual production are three emerging media techniques revolutionizing the media and entertainment industry. Our research project at NYU Tandon @ The Yard aims to compare these three techniques and evaluate their effectiveness against each other through the production of an experimental fashion film. The results showcase the three completed demos, highlighting the distinct visual and practical outcomes of each technique.

Background

NYU Tandon @ The Yard's volumetric capture rig is set up by Evercoast and houses 29 Intel Depth Cameras, to capture both depth and color images. They get merged into a volumetric format, to be either live streamed or imported in game engines as a sequence of 3D models. Motion capture, using Motive software and OptiTrack cameras, tracks and captures the motion of retroreflective markers attached to people and objects, delivering real-time motion data with unparalleled accuracy. Virtual production utilizes a real-time game engine like Unreal Engine, to display virtual environments on massive LED screens, enabling real-world actors to interact with these environments seamlessly.

Methodology and Results

After assembling a film crew for virtual production and inviting the models for volumetric capture and motion capture on a separate day, we set out to composite the scans, footage and data from these shoots.

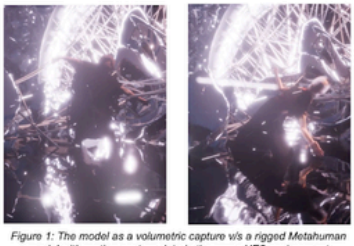


Figure 1: The model as a volumetric capture w/s a rigged Metahuman model with motion capture data in the same UE5 environment

Volumetric Capture

The volumetric capture of the models, were imported into our Unreal Engine environment. They were found to be especially useful in capturing hair and textures in a realistic to semi-realistic manner. Their limitation lie in their artifacts, like the flattening of faces or the glitches that would appear during faster movements.

Motion Capture

The motion data from the capture was streamed to Unreal Engine and then rigged onto a MetaHuman model. This allows for customizations to the model's character design and clothing that wouldn't be possible in "the physical world". However, the work invested in re-creating realistic characters, clothing or props for a 3D setting is often more time consuming and less realistic than the other two methods.

Virtual Production / In-Camera VFX (ICVFX)

While acknowledging the limitations of working with a smaller crew for our ICVFX setup, we can still see the pipeline shine in creating immersive production environments. This allows us to capture the subjects and the fashion collection realistically during production, but limited us to a 2D capture only. Another limitation with this pipeline is the noticeable parallax, or disconnect between actors and their backgrounds. This can be countered with appropriate camera motion tracking and lighting setups.

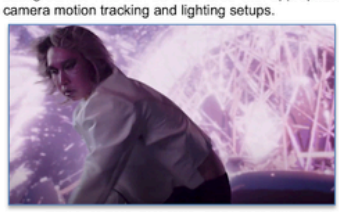


Figure 2: The model in the same Unreal Engine environment as Figure 1 during the virtual production stage

Conclusion and Future Work

Each pipeline has unique affordances and challenges. By understanding their utilities, we can harness their potential for innovative media productions and use them in their relevant scenarios. Future work would involve running these productions in different contexts and modalities of productions like advertisements, sports broadcasts and narrative film production. It would also be worth testing the ICVFX pipeline with industry standard camera tracking setup like stYpe.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. The authors also thank Professor Luke Dubois, Professor Todd Bryant and Adi Somian for all their technical assistance at NYU Tandon @ The Yard facility.

The Development of Hands-On Projects for First-Year Engineering Students

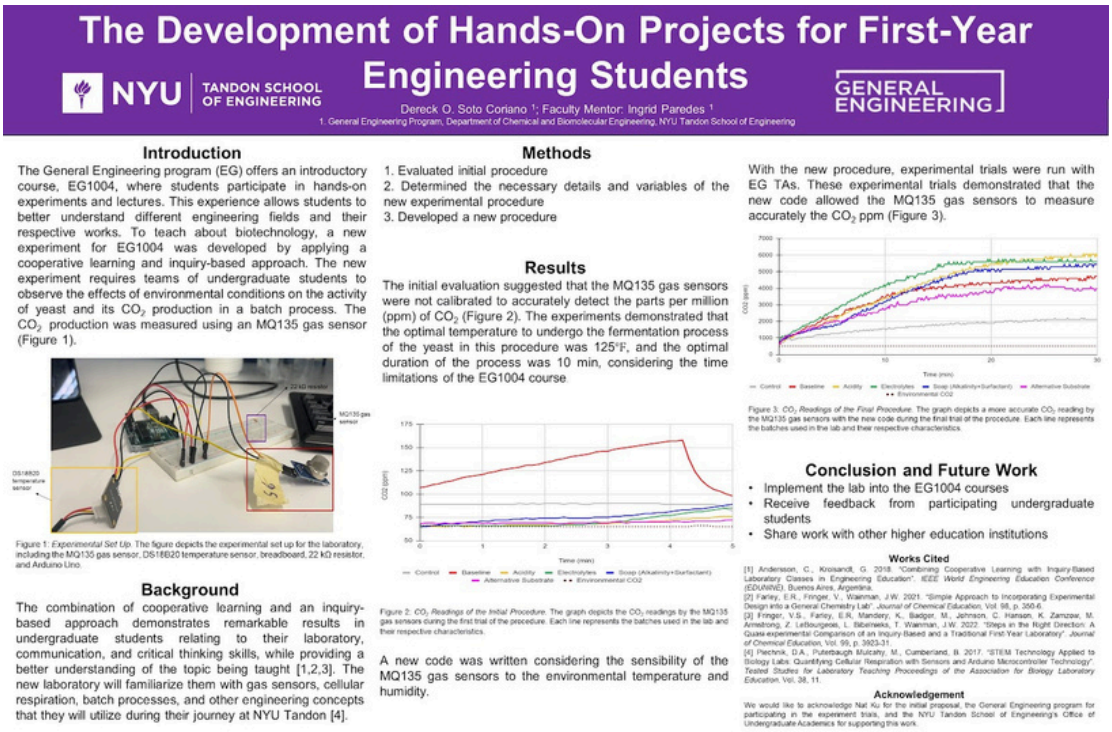
NYU Tandon students are introduced to engineering concepts during their first year at the university. The General Engineering program offers an introductory course, EG1004, where students can participate in hands-on experiments and engineering lectures. This engineering experience allows students to better understand the different engineering fields and their respective works. To teach about biotechnology and its applications, a new experiment for EG1004 was developed by applying a cooperative learning and inquiry-based approach. The new experiment requires teams of undergraduate students to observe the effects of environmental conditions, such as acidity and alkalinity, on the activity of S. Cerevisiae and its CO2 production in a batch process. The CO2 production was measured using an MQ135 gas sensor. We conducted evaluations and trials to measure the effectiveness of this initial procedure. The results suggested that the MQ135 sensors utilized in this experiment were not calibrated to measure CO2 and the procedure had to be edited. Throughout this analysis, we wrote a new code that allows the MQ135 sensors to calibrate and only measure the production of CO2, while also revising and editing the procedure and its variables. After trials with undergraduate students, the final procedure was developed with functional MQ135 sensors and a successful experiment. We expect to implement this new experiment into the EG1004 courses for the next academic year and receive feedback from undergraduate students. Through this process, we seek to establish an engineering experiment for undergraduate students that allows a cooperative learning and inquiry -based approach that remains applicable beyond our institution.

Project Supervisor Ingrid Paredes

Research Areas Emerging Media



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The Development of Hands-On Projects for First-Year Engineering Students

NYU TANDON SCHOOL OF ENGINEERING

Dereck O. Soto Coriano [1]; Faculty Mentor: Ingrid Paredes [1]

1. General Engineering Program, Department of Chemical and Biomolecular Engineering, NYU Tandon School of Engineering

GENERAL ENGINEERING

Introduction

The General Engineering program (EG) offers an introductory course, EG1004, where students participate in hands-on experiments and lectures. This experience allows students to better understand different engineering fields and their respective works. To teach about biotechnology, a new experiment for EG1004 was developed by applying a cooperative learning and inquiry-based approach. The new experiment requires teams of undergraduate students to observe the effects of environmental conditions on the activity of yeast and its CO_2 production in a batch process. The CO_2 production was measured using an MQ135 gas sensor (Figure 1).

Figure 1: *Experimental Set Up.* The figure depicts the experimental set up for the laboratory, including the MQ135 gas sensor, DS18B20 temperature sensor, breadboard, 22 kΩ resistor, and Arduino Uno.

Background

The combination of cooperative learning and an inquiry-based approach demonstrates remarkable results in undergraduate students relating to their laboratory, communication, and critical thinking skills, while providing a better understanding of the topic being taught [1,2,3]. The new laboratory will familiarize them with gas sensors, cellular respiration, batch processes, and other engineering concepts that they will utilize during their journey at NYU Tandon [4].

Methods

1. Evaluated initial procedure
2. Determined the necessary details and variables of the new experimental procedure
3. Developed a new procedure

Results

The initial evaluation suggested that the MQ135 gas sensors were not calibrated to accurately detect the parts per million (ppm) of CO_2 (Figure 2). The experiments demonstrated that the optimal temperature to undergo the fermentation process of the yeast in this procedure was 125°F, and the optimal duration of the process was 10 min, considering the time limitations of the EG1004 course.

Figure 2: *CO_2 Readings of the Initial Procedure.* The graph depicts the CO_2 readings by the MQ135 gas sensors during the first trial of the procedure. Each line represents the batches used in the lab and their respective characteristics.

A new code was written considering the sensibility of the MQ135 gas sensors to the environmental temperature and humidity.

With the new procedure, experimental trials were run with EG TAs. These experimental trials demonstrated that the new code allowed the MQ135 gas sensors to measure accurately the CO_2 ppm (Figure 3).

Figure 3: *CO_2 Readings of the Final Procedure.* The graph depicts a more accurate CO_2 reading by the MQ135 gas sensors with the new code during the final trial of the procedure. Each line represents the batches used in the lab and their respective characteristics.

Conclusion and Future Work

- Implement the lab into the EG1004 courses
- Receive feedback from participating undergraduate students
- Share work with other higher education institutions

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Acknowledgement

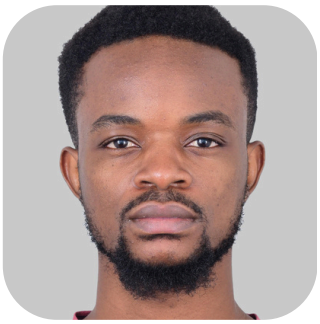
We would like to acknowledge Nat Xu for the initial proposal, the General Engineering program for participating in the experiment trials, and the NYU Tandon School of Engineering's Office of Undergraduate Academics for supporting this work.

Wearable Electronics for Learning

Creative computing learning environments stimulate K-12 learners' interest in STEM fields and support inclusivity in computing. However, instructors often face challenges when striving to remain authentic to artistic expressions while also building learners' competencies in computing and STEM. Following previous co-design processes with community partner STEM from Dance, our team incorporated direct feedback from learners and educators to improve the usability of a wearable prototyping toolkit, "DanceBits," ensuring it remains small, durable, and easily integrated into costumes to meet the constraints of dance contexts. We updated the control boards, JST connectors, and LED strips to ensure easy access, flexibility, durability, and secure connections. These revisions ensure the designs withstand dynamic dance movements. In addition, we designed a 3D printable case to house the control board and battery, that can easily be attached to the performer with a velcro strap. We also focused on optimizing the assembly run with a global manufacturer to keep costs low for our custom system, ensuring it remains sustainable and replicable for our partners. The designs were distributed to STEM from Dance summer camps across the nation, in our first-ever large scale test of the DanceBits system. Before distribution, we developed documentation for instructors and learners to assist with the adoption of a new tool, including example projects and code for the learners to remix into their own projects, which is intrinsic to the DIY style of learning. The hardware for STEM from Dance is currently being used at a summer camp at NYU, where we plan to collect data from the users through observations of the learning environment, with a focus on usability of the hardware and its potential to support authentic creative computing.

Project Supervisor Kathleen McDermott

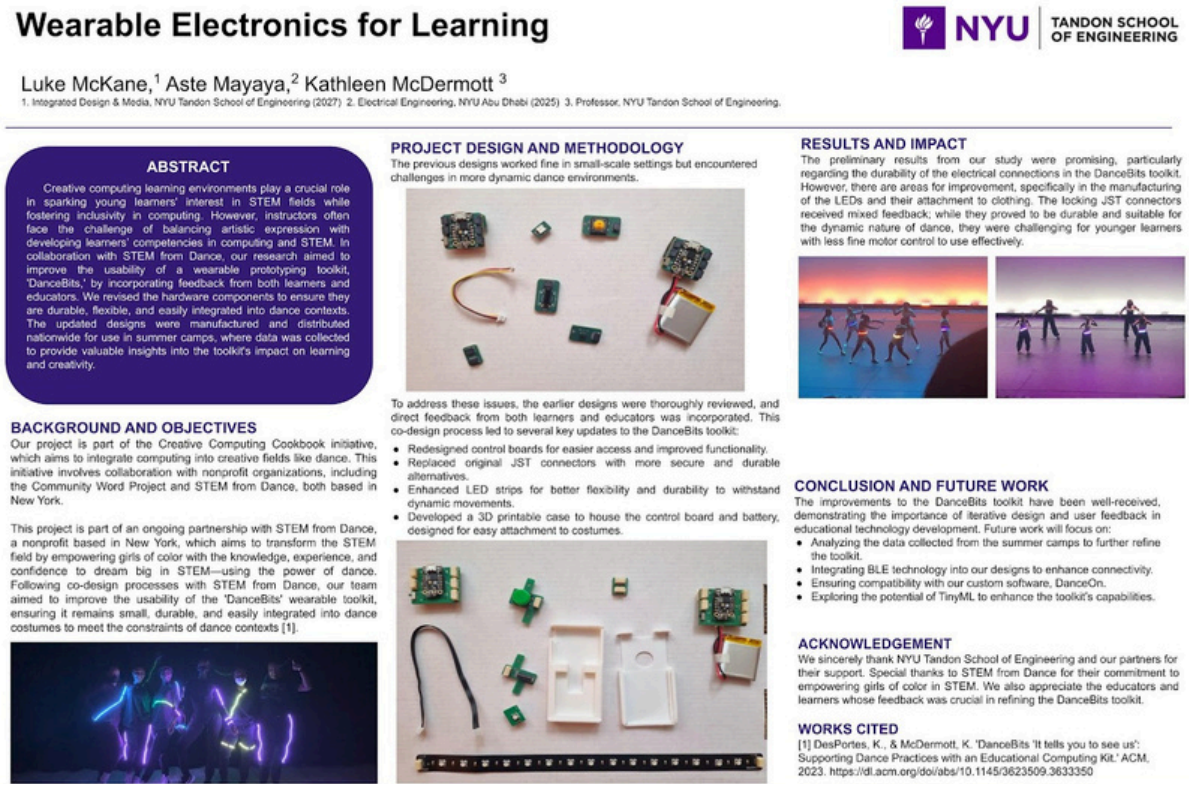
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Wearable Electronics for Learning

NYU TANDON SCHOOL OF ENGINEERING

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ABSTRACT

Creative computing learning environments play a crucial role in sparking young learners' interest in STEM fields while fostering inclusivity in computing. However, instructors often face the challenge of balancing artistic expression with developing learners' competencies in computing and STEM. In collaboration with STEM from Dance, our research aimed to improve the usability of a wearable prototyping toolkit, 'DanceBits,' by incorporating feedback from both learners and educators. We revised the hardware components to ensure they are durable, flexible, and easily integrated into dance contexts. The updated designs were manufactured and distributed nationwide for use in summer camps, where data was collected to provide valuable insights into the toolkit's impact on learning and creativity.

BACKGROUND AND OBJECTIVES

Our project is part of the Creative Computing Cookbook initiative, which aims to integrate computing into creative fields like dance. This initiative involves collaboration with nonprofit organizations, including the Community Word Project and STEM from Dance, both based in New York.

This project is part of an ongoing partnership with STEM from Dance, a nonprofit based in New York, which aims to transform the STEM field by empowering girls of color with the knowledge, experience, and confidence to dream big in STEM—using the power of dance. Following co-design processes with STEM from Dance, our team aimed to improve the usability of the 'DanceBits' wearable toolkit, ensuring it remains small, durable, and easily integrated into dance costumes to meet the constraints of dance contexts [1].

PROJECT DESIGN AND METHODOLOGY

The previous designs worked fine in small-scale settings but encountered challenges in more dynamic dance environments.

To address these issues, the earlier designs were thoroughly reviewed, and direct feedback from both learners and educators was incorporated. This co-design process led to several key updates to the DanceBits toolkit:

- Redesigned control boards for easier access and improved functionality.
- Replaced original JST connectors with more secure and durable alternatives.
- Enhanced LED strips for better flexibility and durability to withstand dynamic movements.
- Developed a 3D printable case to house the control board and battery, designed for easy attachment to costumes.

RESULTS AND IMPACT

The preliminary results from our study were promising, particularly regarding the durability of the electrical connections in the DanceBits toolkit. However, there are areas for improvement, specifically in the manufacturing of the LEDs and their attachment to clothing. The locking JST connectors received mixed feedback; while they proved to be durable and suitable for the dynamic nature of dance, they were challenging for younger learners with less fine motor control to use effectively.

CONCLUSION AND FUTURE WORK

The improvements to the DanceBits toolkit have been well-received, demonstrating the importance of iterative design and user feedback in educational technology development. Future work will focus on:

- Analyzing the data collected from the summer camps to further refine the toolkit.
- Integrating BLE technology into our designs to enhance connectivity.
- Ensuring compatibility with our custom software, DanceOn.
- Exploring the potential of TinyML to enhance the toolkit's capabilities.

ACKNOWLEDGEMENT

We sincerely thank NYU Tandon School of Engineering and our partners for their support. Special thanks to STEM from Dance for their commitment to empowering girls of color in STEM. We also appreciate the educators and learners whose feedback was crucial in refining the DanceBits toolkit.

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3D Image Point Cloud Generation

Point cloud video processing is a process that uses volumetric captures to generate 3D images which are seen in various technological advances today, such as virtual reality. Our goal is to calibrate a 29-camera setup and produce three registrations which should indicate the progressive alignment of different captures. To do so, we applied several machine-learning and linear algebra techniques, including using a RANSAC algorithm and matrix multiplication on the resulting camera transformations. We chose the frames where both the source and target cameras show the calibration board fully and found the transformation matrix between those cameras. This method allowed us to ensure the two captures from the cameras would align properly upon global and colored registration. In addition, we removed background noises to improve the accuracy of the calibration. This was done by filtering out any green points and adjusting the depth range of the image to leave only the person (and board) in the generated point cloud. Our final step was combining the transformations we found during calibration to generate a complete point cloud. With these results, we were able to produce a point cloud 3D video which functions similarly to a traditional 2D display but requires less time and power.

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3D Image Point Cloud Generation

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Abstract

Point cloud video processing is a process that uses volumetric captures to generate 3D images which are seen in various technological advances today, such as virtual reality. We calibrated a 29-camera setup and produced a complete 3D point cloud generated by three registrations to indicate the progressive alignment of different captures.

Methodology

We chose the frames where both the source and target cameras show the calibration board fully and found the transformation matrix between those cameras. This method allowed us to ensure the two captures from the cameras, starting with initial registration, would align properly upon global and colored registration (Figure 1). Colored registration [1] follows global registration [2] and produces a more accurate alignment than the latter. We also removed background noises to improve the accuracy of the calibration by filtering out any green points and adjusting the depth range of the image to leave only the person (and board) in the generated point cloud. Our final step was combining the transformations we found during calibration to generate a complete point cloud. We need to have a set target camera so all the other cameras have a consistent point to merge their captures and form a final point cloud image in the end.

Therefore, we used matrix multiplication with the previous transformation matrices to calculate the transformation matrices between the chosen target camera and the rest of the cameras.



Figure 1: Three Registrations (Initial, Global, Colored)

Test Environment

We used Evercoast's 29-camera volumetric capture studio to take front-facing 3D images using a board, which were used to calibrate the system (Figure 2). We used Python, specifically Anaconda and NumPy, to code and run our program, and Open3D software to visualize our final results.



Figure 2: Evercoast Camera Setup

Conclusion

Using the point cloud 3D image, we want to produce a point cloud 3D video. As opposed to a traditional 2D display, point clouds reduce the bandwidth and latency of videos to make streaming easier so less time and power is required to run the 3D model. Our next steps include making the complete point cloud have fewer noises caused by the inaccurate depth images and improving alignment through eliminating inconsistencies between transformations. In Figure 3, we attempted a statistical outlier removal method to remove unwanted points based on the standard deviation from the central point cloud. While the results (shown on the far right) prove to be somewhat successful, improvement is still needed.

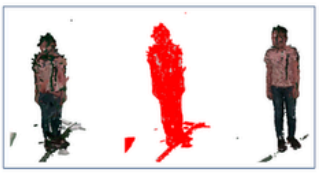


Figure 3: Point Cloud 3D Image After Statistical Outlier Removal

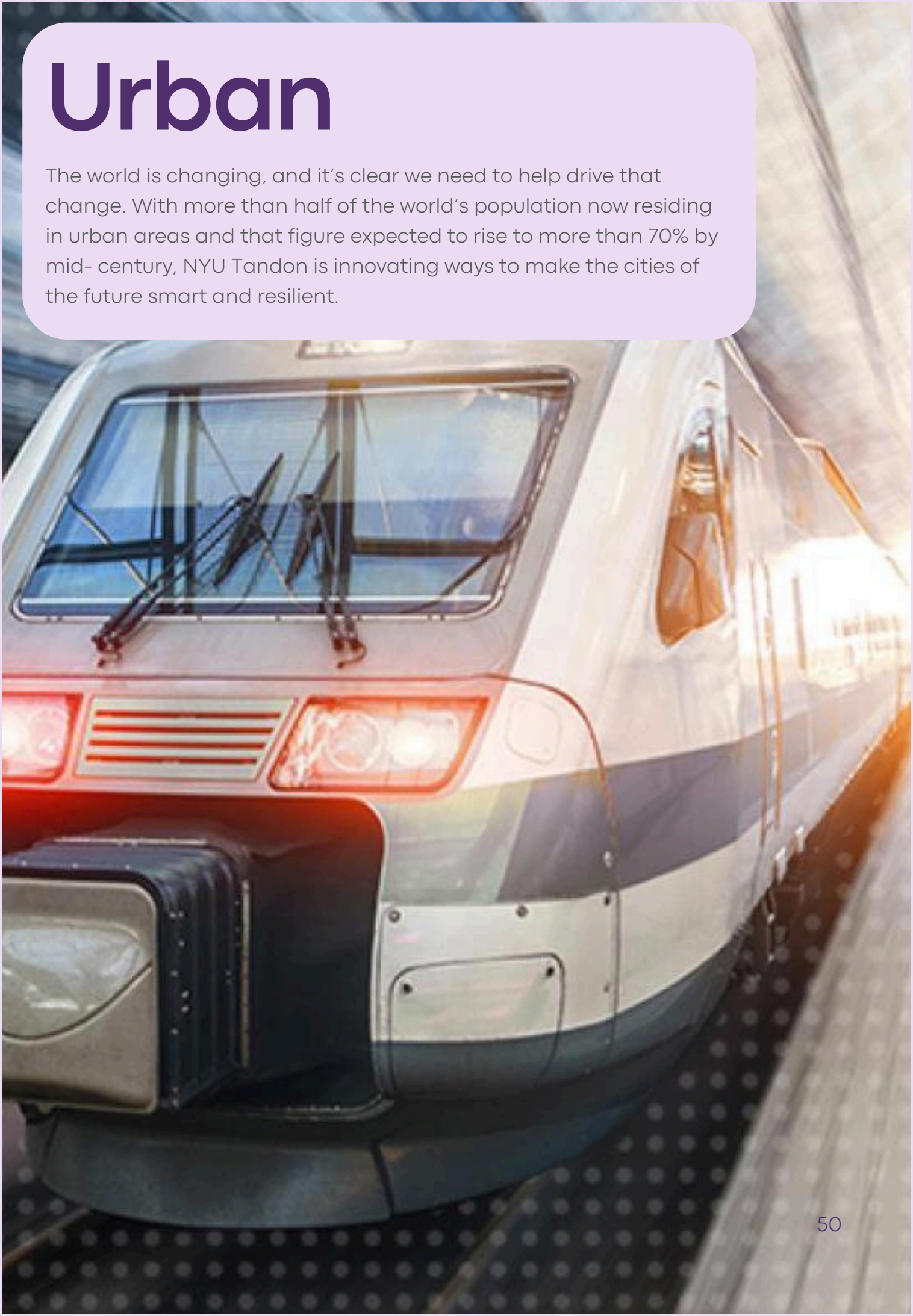
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Urban

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.



Mobile Data Insights into NYC Park Visitor Behavior

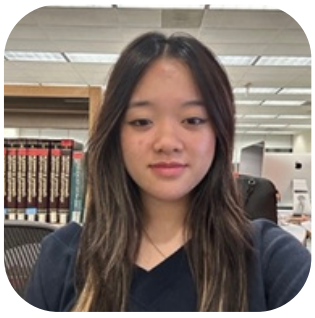
New York City is often seen as an epicenter of diversity, a reflection of this showcased by its public parks. Public parks serve as vital spaces for exercise, social interactions, and reconnection with nature. Despite the city's vibrant park culture, there is limited understanding of the specific interactions that occur within these green spaces and the broader impacts they have on surrounding neighborhoods. In this study, we utilize mobile phone data to analyze patterns of park usage and their effects on nearby areas. Our findings reveal that New York City's public parks attract a highly diverse group of visitors, with demographic patterns varying significantly by the facilities offered at each of the parks. Additionally, parks with more diverse amenities, such as sports facilities, playgrounds, and cultural events, tend to draw a wider range of age groups and cultural backgrounds. The broader implications of these results underscore the importance of urban parks in promoting social cohesion and economic vitality in urban environments. By leveraging mobile phone data, our study provides a fine-scale analysis of visitation patterns, addressing gaps identified in previous research and offering actionable insights for urban planning and park management. This research highlights the evolving role of public parks in enhancing community well-being and adapting to urban challenges.

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Mobile Data Insights into NYC Park Visitor Behavior

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Abstract

New York City is often seen as an epicenter of diversity, a reflection of this showcased by its public parks. Public parks serve as vital spaces for exercise, social interactions, and reconnection with nature. Despite the city's vibrant park culture, there is limited understanding of the specific interactions that occur within these green spaces and the broader impacts they have on surrounding neighborhoods. In this study, we utilize mobile phone data to analyze patterns of park usage and their effects on nearby areas. Our findings reveal that New York City's public parks attract a highly diverse group of visitors, with demographic patterns varying significantly by the facilities offered at each of the parks. Additionally, parks with more diverse amenities, such as sports facilities, playgrounds, and cultural events, tend to draw a wider range of age groups and cultural backgrounds.

Methods

We utilized the Placer.ai website to analyze park demographics and visitation patterns, gaining insights into visitor origins and behaviors. Additionally, we conducted in-person observations at Commodore Barry Park and Fort Greene Park to directly observe visitor activities and interactions. These combined approaches allowed us to achieve a comprehensive understanding of park usage and visitor dynamics.

Figure 3 (pictured left): Visitor Origins for Fort Greene Park. This map illustrates the geographic origins of visitors to Fort Greene Park. Areas shaded in pink represent the top 30% of visitor origins, orange indicates the top 50%, and purple shows the top 70%. The visualization highlights how proximity contributes to park visitation.

Figure 4 (pictured above): Fort Greene Park on a Hot Summer Morning. This photograph showcases visitors utilizing the amenities of Fort Greene Park on a warm summer morning, including people sitting on benches, walking, and playing tennis. The image highlights the park's vibrant community engagement and active recreational use.

Ethnicity of Park Visitors

Fort Greene Park Commodore Barry Park

Percent of Visitors

50.00% 40.00% 30.00% 20.00% 10.00% 0.00%

White Black Hispanic or Latino American Indian or Alaska Native Asian Native Hawaiian or Other Pacific Islander Other Two or more

Figure 1: Ethnicity Breakdown of Visitors in Two Brooklyn Parks. This bar graph compares the ethnic composition of visitors at Commodore Barry Park and Fort Greene Park. The data highlights the diverse demographics of park goers, illustrating the varying ethnic distributions despite the extremely close proximity of these parks

Results

Our observations at Fort Greene Park revealed notable demographic differences between visitors on the north and south sides of the park. These variations suggest that even within a single park, visitor demographics can differ significantly.
We also observed visitors actively utilizing various amenities, including benches, playgrounds, green spaces, and athletic facilities. While we witnessed social interactions, such as fitness classes and activities for children, many visitors were present alone or in pairs with friends. This indicates that while parks may not necessarily create new social interactions, they play a vital role in fostering existing relationships and enhancing community engagement.

Relevence

These findings highlight the crucial role urban parks play in fostering social cohesion and economic vitality within city environments. Utilizing mobile phone data, we have a detailed analysis of visitation patterns, filling gaps identified in previous research and providing actionable insights for urban planning and park management. This research underscores the evolving significance of public parks in promoting community well-being and addressing urban challenges.

Acknowledgement

We would like to express our sincere gratitude to our mentors, Professors Graham Dove and Takahiro Yabe, for their invaluable guidance, support, and expertise throughout this research project. Their insightful feedback and encouragement were important in the duration of this project.

EV Infrastructure

New York City (NYC) aims to cut GHG emissions by 80% from 2005 levels by 2050. Transitioning the city'sextensive municipal fleet to electric vehicles (EVs) is acrucial step in this plan. This project aims to determineoptimal locations of shared charging stations for selectNYC municipal fleets to promote wider EV adoption. Weperform a spatiotemporal analysis of select NYC vehiclefleets by analysing fleet operation & mobility patterns,charging needs, and neighborhood power constraints.This project contains three major sub-problems: 1)modeling & optimizing fleet coverage area, 2) modelingEV charging requirements and needs, and 3) optimizingthe placement of charging stations. We extend existingresearch on modeling fleet coverage area by introducinga more comprehensive multi-objective optimizationmodel. We carry out a real-life case study of the SunsetPark region in Brooklyn and model operations of select DSNY fleets. We use Sunset Park population and area to estimate DSNY local fleet task loads, which are a key component in determining a vehicle's coverage area. Our project presents a novel Probabilistic Greedy Capacitated Clustering (PGCC) algorithm to solve the coverage area multi-objective optimization problem. Further, we integrate existing research on EV charging and develop a comprehensive and realistic model for fleet charging. In addition, we develop an optimization model and a novel algorithm to optimize charging station locations within Sunset Park. Our study sets an example for municipal fleets and shows that shared/collaborative charging can reduce costs & wait times and contribute to a smoother transition from gasoline to electric fleets.

Project Supervisor Debra Laefer

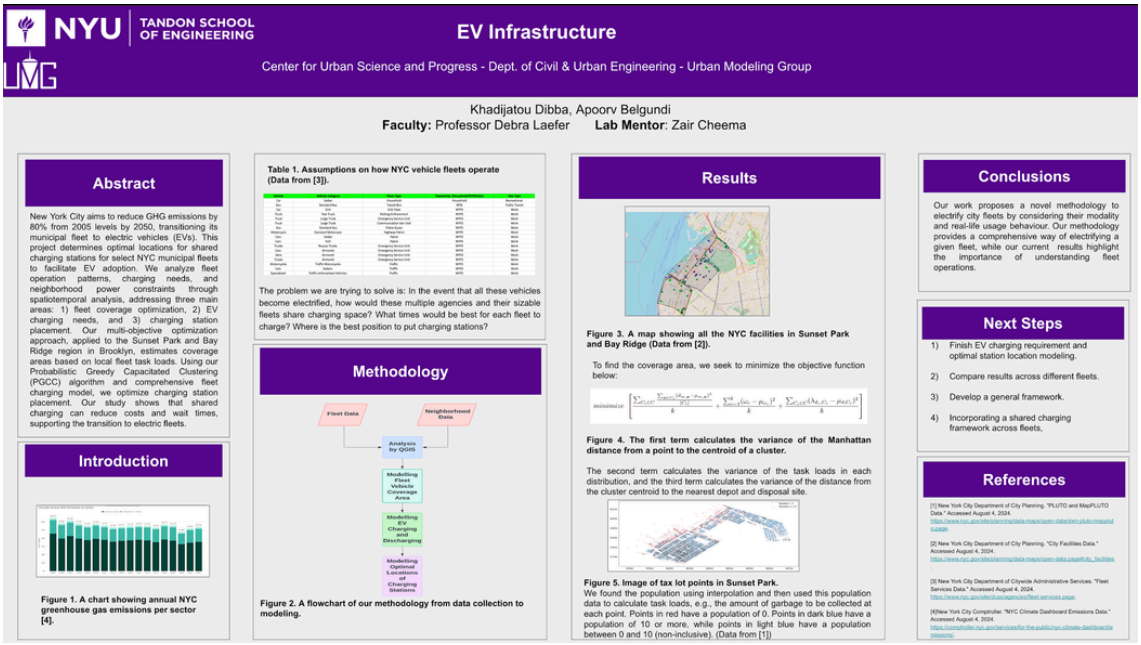
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Mapping Lost Cemeteries in NYC

In old cities like New York, a rapidly shifting urban landscape can obfuscate the history of the land itself, leading to unintended discoveries during construction projects. Striking unexpected human remains, aside from being unsettling, can cause significant delays and cost overruns. The creation of a comprehensive dataset comprised of burial sites (lost, moved, or otherwise unmarked) can provide developers, city officials, and the general public with an invaluable resource with which to navigate the city's hidden underground. This project expands upon the groundwork laid by the New York City Cemetery Project, which researched hundreds of past and present cemeteries within the modern city limits. Evidence for the locations of cemeteries that do not appear in modern databases is found in historical maps and atlases provided by sources such as the Library of Congress and New York Public Library Digital Collection. Georeferencing such historical maps using the ArcGIS software suite provides the modern coordinates of sites that were once burying grounds. To further the understanding of what can affect or predict the location of a cemetery, extensive metadata is cataloged for every cemetery in the city, allowing for the observation of trends. The result of this project is a publicly-accessible online tool for anyone that would like to see where cemeteries once existed in New York City, in addition to a wealth of information about how they have come and gone over time. For anyone wishing to develop land in the city without waking the dead, referencing this tool will be a simple and effective way to evaluate the need for extra precaution when ground is broken.

Project Supervisor Debra Laefer

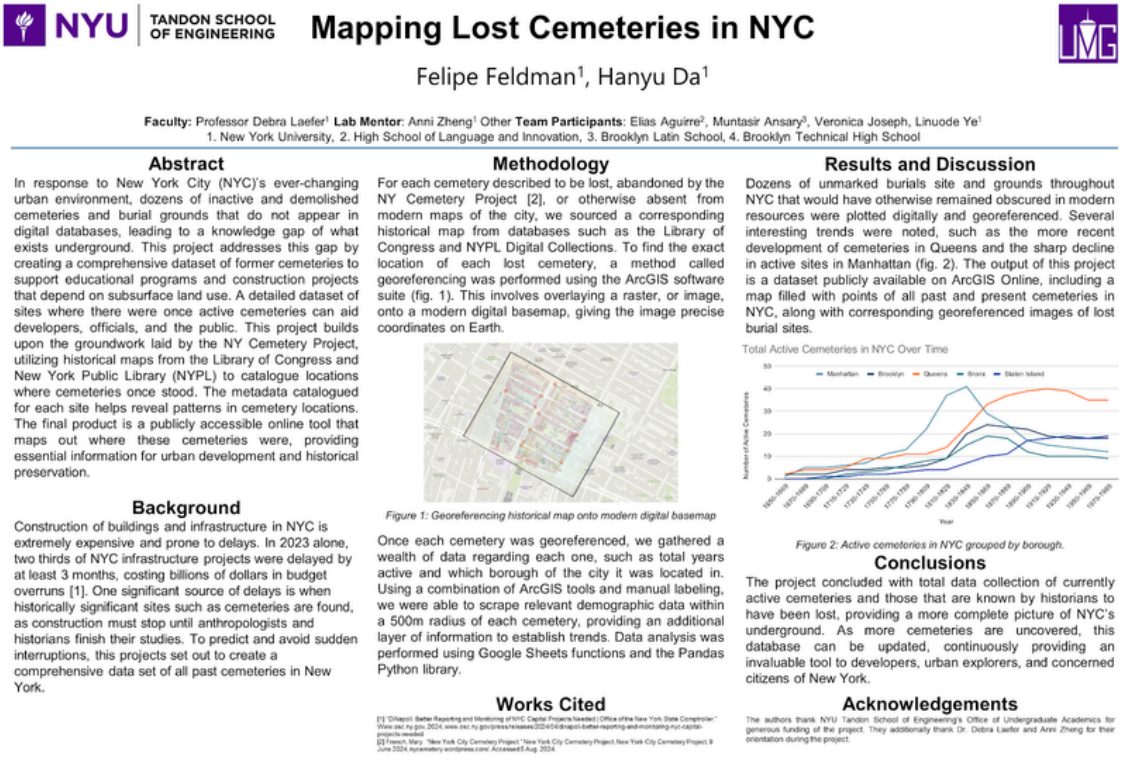
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Mapping Lost Cemeteries in NYC

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Abstract

In response to New York City (NYC)'s ever-changing urban environment, dozens of inactive and demolished cemeteries and burial grounds that do not appear in digital databases, leading to a knowledge gap of what exists underground. This project addresses this gap by creating a comprehensive dataset of former cemeteries to support educational programs and construction projects that depend on subsurface land use. A detailed dataset of sites where there were once active cemeteries can aid developers, officials, and the public. This project builds upon the groundwork laid by the NY Cemetery Project, utilizing historical maps from the Library of Congress and New York Public Library (NYPL) to catalogue locations where cemeteries once stood. The metadata catalogued for each site helps reveal patterns in cemetery locations. The final product is a publicly accessible online tool that maps out where these cemeteries were, providing essential information for urban development and historical preservation.

Background

Construction of buildings and infrastructure in NYC is extremely expensive and prone to delays. In 2023 alone, two thirds of NYC infrastructure projects were delayed by at least 3 months, costing billions of dollars in budget overruns [1]. One significant source of delays is when historically significant sites such as cemeteries are found, as construction must stop until anthropologists and historians finish their studies. To predict and avoid sudden interruptions, this projects set out to create a comprehensive data set of all past cemeteries in New York.

Methodology

For each cemetery described to be lost, abandoned by the NY Cemetery Project [2], or otherwise absent from modern maps of the city, we sourced a corresponding historical map from databases such as the Library of Congress and NYPL Digital Collections. To find the exact location of each lost cemetery, a method called georeferencing was performed using the ArcGIS software suite (fig. 1). This involves overlaying a raster, or image, onto a modern digital basemap, giving the image precise coordinates on Earth.

Figure 1: Georeferencing historical map onto modern digital basemap

Once each cemetery was georeferenced, we gathered a wealth of data regarding each one, such as total years active and which borough of the city it was located in. Using a combination of ArcGIS tools and manual labeling, we were able to scrape relevant demographic data within a 500m radius of each cemetery, providing an additional layer of information to establish trends. Data analysis was performed using Google Sheets functions and the Pandas Python library.

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Results and Discussion

Dozens of unmarked burials site and grounds throughout NYC that would have otherwise remained obscured in modern resources were plotted digitally and georeferenced. Several interesting trends were noted, such as the more recent development of cemeteries in Queens and the sharp decline in active sites in Manhattan (fig. 2). The output of this project is a dataset publicly available on ArcGIS Online, including a map filled with points of all past and present cemeteries in NYC, along with corresponding georeferenced images of lost burial sites.

Figure 2: Active cemeteries in NYC grouped by borough.

Conclusions

The project concluded with total data collection of currently active cemeteries and those that are known by historians to have been lost, providing a more complete picture of NYC's underground. As more cemeteries are uncovered, this database can be updated, continuously providing an invaluable tool to developers, urban explorers, and concerned citizens of New York.

Acknowledgements

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. They additionally thank Dr. Debra Laefer and Anni Zheng for their orientation during the project.

Assessing the Validity of GAN-Generated Population Data Through Marginal and Diversity Analysis

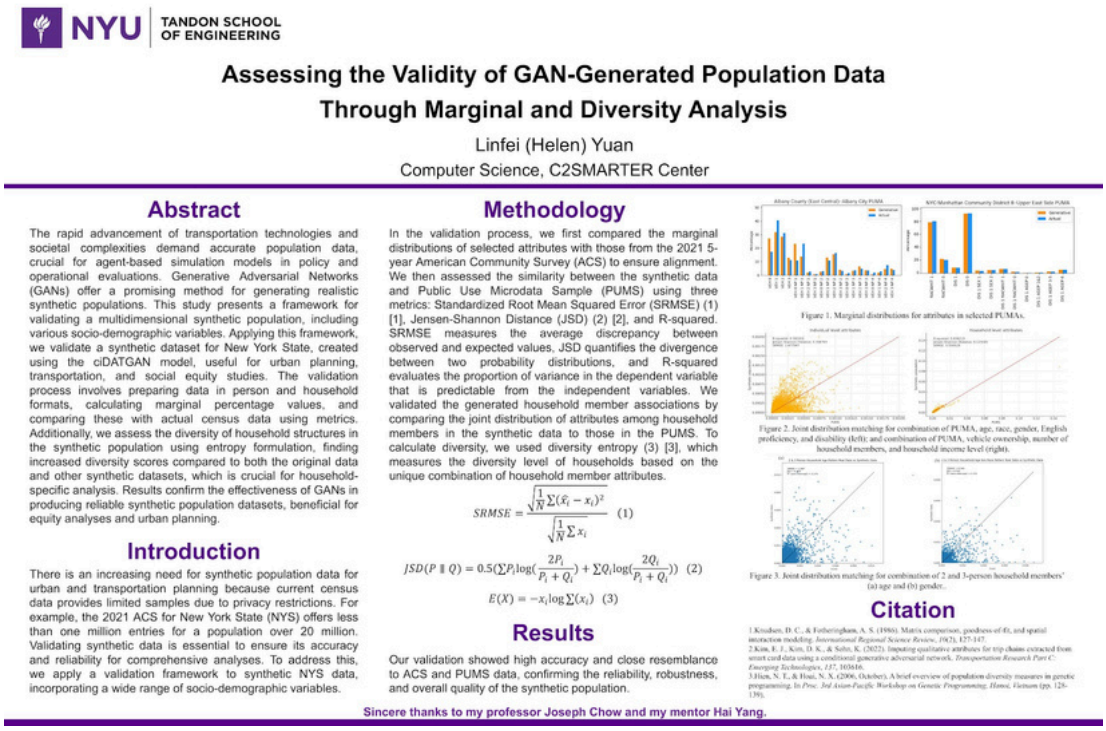
The accelerated evolution of transportation technologies and the growing complexity of modern societies underscore the need for comprehensive and precise population data. Synthetic population data plays a pivotal role in this context, facilitating the use of agent-based simulation models for policy and operational evaluations. Generative Adversarial Networks (GANs) have emerged as a promising solution for the generation of realistic synthetic populations. This study provides a framework to thoroughly validate a multidimensional synthetic population encompassing various socio-demographic variables. We apply this framework to validate a synthetic population dataset for New York State, generated using the Conditional Input Directed Acyclic Tabular Generative Adversarial Network (ciDATGAN). The model synthesizes population data with a range of attributes that are valuable for urban planning, transportation, and social equity studies. The validation process entailed the preparation of the data in both person and household formats, the calculation of marginal percentage values for each attribute and combinations of attributes within each Public Use Microdata Area (PUMA), and a comparison of these values to actual census data. Quantitative assessments were conducted using the Standardized Root Mean Squared Error (SRMSE) and Jensen-Shannon Distance (JSD) metrics to evaluate the similarity between the synthetic population and the actual data. The results of this study demonstrate the efficacy of GANs in producing reliable synthetic population datasets, offering a valuable resource for comprehensive equity analyses and informed urban planning.

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NYU TANDON SCHOOL OF ENGINEERING

Assessing the Validity of GAN-Generated Population Data Through Marginal and Diversity Analysis

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Abstract

The rapid advancement of transportation technologies and societal complexities demand accurate population data, crucial for agent-based simulation models in policy and operational evaluations. Generative Adversarial Networks (GANs) offer a promising method for generating realistic synthetic populations. This study presents a framework for validating a multidimensional synthetic population, including various socio-demographic variables. Applying this framework, we validate a synthetic dataset for New York State, created using the ciDATGAN model, useful for urban planning, transportation, and social equity studies. The validation process involves preparing data in person and household formats, calculating marginal percentage values, and comparing these with actual census data using metrics. Additionally, we assess the diversity of household structures in the synthetic population using entropy formulation, finding increased diversity scores compared to both the original data and other synthetic datasets, which is crucial for household-specific analysis. Results confirm the effectiveness of GANs in producing reliable synthetic population datasets, beneficial for equity analyses and urban planning.

Introduction

There is an increasing need for synthetic population data for urban and transportation planning because current census data provides limited samples due to privacy restrictions. For example, the 2021 ACS for New York State (NYS) offers less than one million entries for a population over 20 million. Validating synthetic data is essential to ensure its accuracy and reliability for comprehensive analyses. To address this, we apply a validation framework to synthetic NYS data, incorporating a wide range of socio-demographic variables.

Methodology

In the validation process, we first compared the marginal distributions of selected attributes with those from the 2021 5-year American Community Survey (ACS) to ensure alignment. We then assessed the similarity between the synthetic data and Public Use Microdata Sample (PUMS) using three metrics: Standardized Root Mean Squared Error (SRMSE) (1) [1], Jensen-Shannon Distance (JSD) (2) [2], and R-squared. SRMSE measures the average discrepancy between observed and expected values, JSD quantifies the divergence between two probability distributions, and R-squared evaluates the proportion of variance in the dependent variable that is predictable from the independent variables. We validated the generated household member associations by comparing the joint distribution of attributes among household members in the synthetic data to those in the PUMS. To calculate diversity, we used diversity entropy (3) [3], which measures the diversity level of households based on the unique combination of household member attributes.

$$SRMSE = \frac{\sqrt{\frac{1}{N}\sum(\bar{x}_i - x_i)^2}}{\sqrt{\frac{1}{N}\sum x_i}} \quad (1)$$

$$JSD(P \parallel Q) = 0.5(\sum P_i \log(\frac{2P_i}{P_i + Q_i}) + \sum Q_i \log(\frac{2Q_i}{P_i + Q_i})) \quad (2)$$

$$E(X) = -x_i \log \sum(x_i) \quad (3)$$

Results

Our validation showed high accuracy and close resemblance to ACS and PUMS data, confirming the reliability, robustness, and overall quality of the synthetic population.

Figure 1. Marginal distributions for attributes in selected PUMAs.

Figure 2. Joint distribution matching for combination of PUMA, age, race, gender, English proficiency, and disability (left); and combination of PUMA, vehicle ownership, number of household members, and household income level (right).

Figure 3. Joint distribution matching for combination of 2 and 3-person household members' (a) age and (b) gender.

Citation

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Sincere thanks to my professor Joseph Chow and my mentor Hai Yang.

Digitizing Transit Accessibility Barriers

As of 2024, two-thirds of New York City's subway stations do not offer step-free access from the street to the platform, making it difficult, or impossible, for certain populations to travel. This study aimed to identify and quantify unaddressed physical obstacles to accessibility in subway stations classified as inaccessible, or those lacking step-free access from street level to platform level. These stations vary in several ways that influence the travel experience, including step count, walking distance, fare gate type, and presence of escalators, but these nuances have not been previously documented. Team members documented data spatially linked to each entrance on paths from station entrances to platforms using an evaluation tool created with a mobile phone survey collection app. The data collected have demonstrated significant variability in several of these physical attributes, including inconsistency in the number of steps from each station entrance to the same platform or the presence of braille throughout the station. This novel data set was organized into a website where the public can view the data and findings and informed a difficulty-rating system intended to assist navigation across inaccessible stations for people with mobility impairments. This study is the largest such survey of the physical attributes of New York City subway stations, and this dataset offers future applications for transit wayfinding tools and subway improvement planners.

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Digitizing Transit Accessibility Barriers

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Abstract

This study aimed to identify and quantify unaddressed physical obstacles to accessing those New York City subway stations without elevators. These stations vary in several ways that influence the travel experience, including number of steps, walking distance, and presence of escalators; nuances which have not been previously documented. Team members built, piloted, and deployed a survey to capture these station details, covering 71 stations (more than 3 full lines). The data collected demonstrates significant variance in these fundamental aspects of stations, including the number of steps from each station entrance to the platform, as well as the presence of braille throughout the station. This novel data set has been organized into a publicly accessible website, which offers future applications for transit wayfinding tools and transportation planners.

Background

The New York City (NYC) subway system is the largest in the United States, carrying roughly 40% of all transit riders nationwide. However, as of 2024, two-thirds of NYC's subway stations do not offer step-free access from the street to the platform and falling short of accessibility standards set by the 1991 Americans with Disabilities Act (ADA).

Fully ADA accessibility will not occur until at least 2055 [1] and a cursory evaluation of the system indicates inaccessible stations vary significantly in ease of reaching the platform. Therefore those with mobility/visual impairments may experience more, or less, difficulty to navigate certain stations as opposed to others.

Figure 1: Inequities seen in stairs at different stations

Methods

A data collection tool was created using Survey123, an application designed to gather geographical survey data that can be synced with GIS platforms. This tool consisted of three surveys, with each covering a separate section of the station: entrance to fare gate, fare gate to platform, and platform. Questions were designed to be as objective as possible in order to minimize subjectivity, with most being either numerical data or binary-choice answers.

Team members then surveyed subway stations (completing one line at a time), for all stations which lack step-free access and are not planned for improvement in the near future.

Results

We surveyed 71 of New York's 306 currently-inaccessible stations. This includes all of the G, J/Z, and L lines, as well as parts of the F, R, and 1 lines. As expected, the barriers to accessibility within inaccessible stations varied significantly from station to station. The median step count from entrance to fare gate is 29 steps with a maximum of 57 and a minimum of 0. The average distance from entrance to fare gate is 43 feet. The average platform width is 12 feet and 2 inches with a maximum of 20 ½ feet and a minimum of 6 feet.

Figure 2: Map of collection progress

Future Work

Going forward this (still expanding) dataset can be integrated into wayfinding applications and inform the schedule of station upgrades.

Works Cited

[1] Gold, M. 2022. "M.T.A. Vows to Make Subways 95% Accessible. It Will Take 33 Years." The New York Times. June 22, 2022. sec. New York. https://www.nytimes.com/2022/06/22/nyregion/nyc-subway-accessibility-disabilities-elevators.html.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Noise Data Visualization for Environmental Justice Advocacy

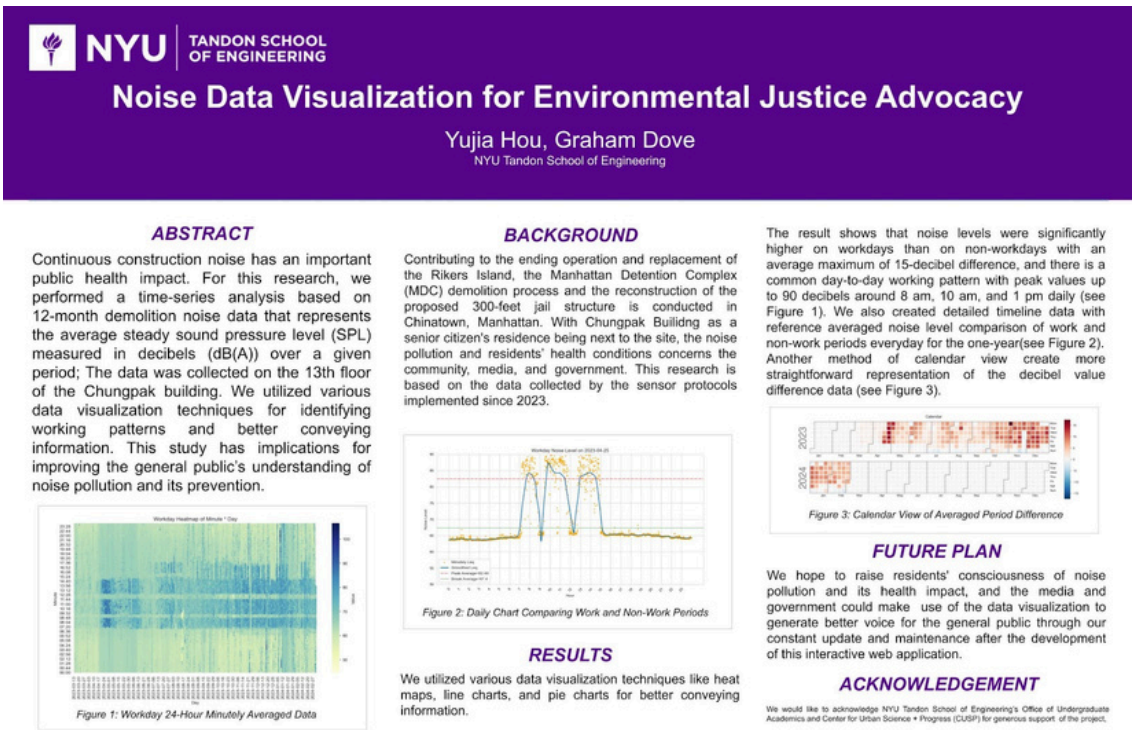
Continuous construction noise has an important public health impact. Contributing to the ending operation and replacement of the Rikers Island, the Manhattan Detention Complex (MDC) demolition process and the reconstruction of the proposed 300-feet jail structure is conducted in Chinatown, Manhattan. The noise pollution next to the major construction site concerns the community, media, and government. For this research, we performed a time-series analysis based on 12-month Leq, Lmax, L90, and L noise data. Leq represents the average steady sound pressure level (SPL) measured in decibels (dB(A)) over a given period; Lmax is the maximum value during the period, and L90 or L is the sound pressure level that exceeds 90% or % of the time. The data was collected on the 13th floor of the Chungpak building which provides affordable housing for senior citizens, and children day care services. The result shows that noise levels were significantly higher on workdays than on non-workdays with an average maximum of 15-decibel difference, and there is a working pattern with peak values around 8 am, am, and 1 pm daily. We utilized various data visualization techniques like heat maps, line charts, and pie charts for better conveying information. A dynamic web application with a calendar view containing an expanded data filtering interface with a detailed timeline noise-level display and interactive health education module was generated. This study has implications for improving the general public's understanding of noise pollution and its prevention.

Project Supervisor Graham Dove

Research Areas Urban



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NYU TANDON SCHOOL OF ENGINEERING

Noise Data Visualization for Environmental Justice Advocacy

Yujia Hou, Graham Dove
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ABSTRACT

Continuous construction noise has an important public health impact. For this research, we performed a time-series analysis based on 12-month demolition noise data that represents the average steady sound pressure level (SPL) measured in decibels (dB(A)) over a given period; The data was collected on the 13th floor of the Chungpak building. We utilized various data visualization techniques for identifying working patterns and better conveying information. This study has implications for improving the general public's understanding of noise pollution and its prevention.

Figure 1: Workday 24-Hour Minutely Averaged Data

BACKGROUND

Contributing to the ending operation and replacement of the Rikers Island, the Manhattan Detention Complex (MDC) demolition process and the reconstruction of the proposed 300-feet jail structure is conducted in Chinatown, Manhattan. With Chungpak Builidng as a senior citizen's residence being next to the site, the noise pollution and residents' health conditions concerns the community, media, and government. This research is based on the data collected by the sensor protocols implemented since 2023.

Figure 2: Daily Chart Comparing Work and Non-Work Periods

RESULTS

We utilized various data visualization techniques like heat maps, line charts, and pie charts for better conveying information.

The result shows that noise levels were significantly higher on workdays than on non-workdays with an average maximum of 15-decibel difference, and there is a common day-to-day working pattern with peak values up to 90 decibels around 8 am, 10 am, and 1 pm daily (see Figure 1). We also created detailed timeline data with reference averaged noise level comparison of work and non-work periods everyday for the one-year(see Figure 2). Another method of calendar view create more straightforward representation of the decibel value difference data (see Figure 3).

Figure 3: Calendar View of Averaged Period Difference

FUTURE PLAN

We hope to raise residents' consciousness of noise pollution and its health impact, and the media and government could make use of the data visualization to generate better voice for the general public through our constant update and maintenance after the development of this interactive web application.

ACKNOWLEDGEMENT

We would like to acknowledge NYU Tandon School of Engineering's Office of Undergraduate Academics and Center for Urban Science + Progress (CUSP) for generous support of the project.

Enhancing Work Zone Safety with VR and CARLA-Based Simulations

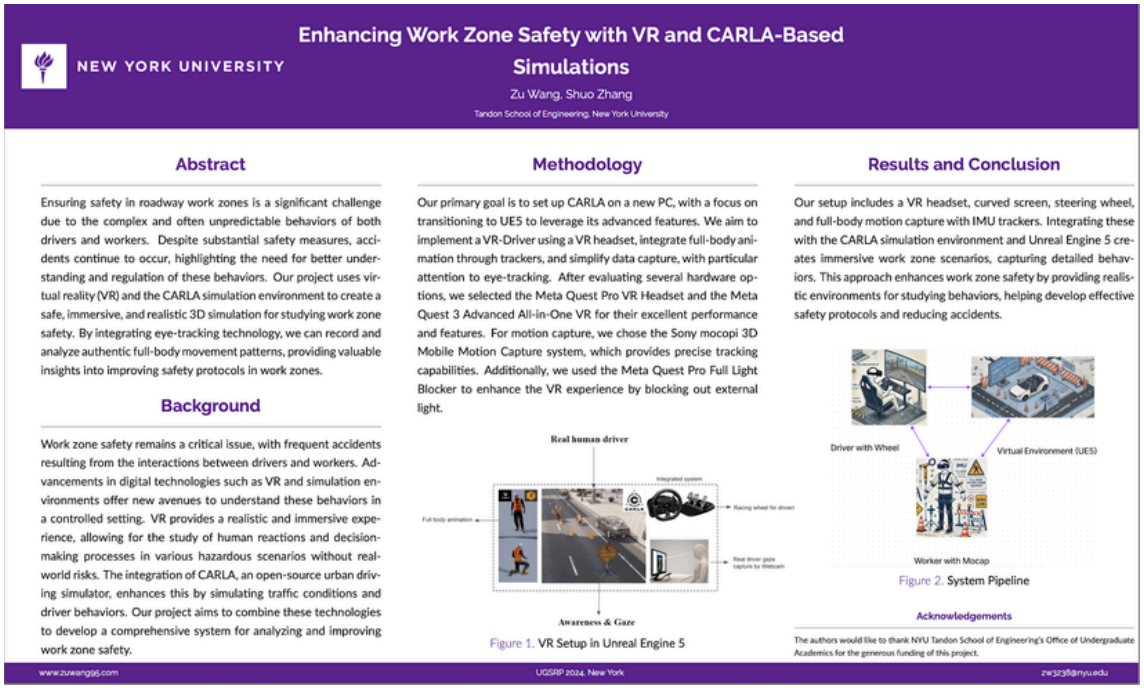
Ensuring safety in roadway work zones is a significant challenge due to the complex and often unpredictable behaviors of both drivers and workers. Despite substantial safety measures, accidents continue to occur, highlighting the need for better understanding and regulation of these behaviors. Our project uses virtual reality (VR) and the CARLA simulation environment to create a safe, immersive, and realistic 3D simulation for studying work zone safety. By integrating eye-tracking technology, we can record and analyze authentic full-body movement patterns, providing valuable insights into improving safety protocols in work zones.

Project Supervisor Semiha Ergan

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Enhancing Work Zone Safety with VR and CARLA-Based Simulations

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Abstract

Ensuring safety in roadway work zones is a significant challenge due to the complex and often unpredictable behaviors of both drivers and workers. Despite substantial safety measures, accidents continue to occur, highlighting the need for better understanding and regulation of these behaviors. Our project uses virtual reality (VR) and the CARLA simulation environment to create a safe, immersive, and realistic 3D simulation for studying work zone safety. By integrating eye-tracking technology, we can record and analyze authentic full-body movement patterns, providing valuable insights into improving safety protocols in work zones.

Background

Work zone safety remains a critical issue, with frequent accidents resulting from the interactions between drivers and workers. Advancements in digital technologies such as VR and simulation environments offer new avenues to understand these behaviors in a controlled setting. VR provides a realistic and immersive experience, allowing for the study of human reactions and decision-making processes in various hazardous scenarios without real-world risks. The integration of CARLA, an open-source urban driving simulator, enhances this by simulating traffic conditions and driver behaviors. Our project aims to combine these technologies to develop a comprehensive system for analyzing and improving work zone safety.

Methodology

Our primary goal is to set up CARLA on a new PC, with a focus on transitioning to UE5 to leverage its advanced features. We aim to implement a VR-Driver using a VR headset, integrate full-body animation through trackers, and simplify data capture, with particular attention to eye-tracking. After evaluating several hardware options, we selected the Meta Quest Pro VR Headset and the Meta Quest 3 Advanced All-in-One VR for their excellent performance and features. For motion capture, we chose the Sony mocopi 3D Mobile Motion Capture system, which provides precise tracking capabilities. Additionally, we used the Meta Quest Pro Full Light Blocker to enhance the VR experience by blocking out external light.

Figure 1. VR Setup in Unreal Engine 5

Results and Conclusion

Our setup includes a VR headset, curved screen, steering wheel, and full-body motion capture with IMU trackers. Integrating these with the CARLA simulation environment and Unreal Engine 5 creates immersive work zone scenarios, capturing detailed behaviors. This approach enhances work zone safety by providing realistic environments for studying behaviors, helping develop effective safety protocols and reducing accidents.

Figure 2. System Pipeline

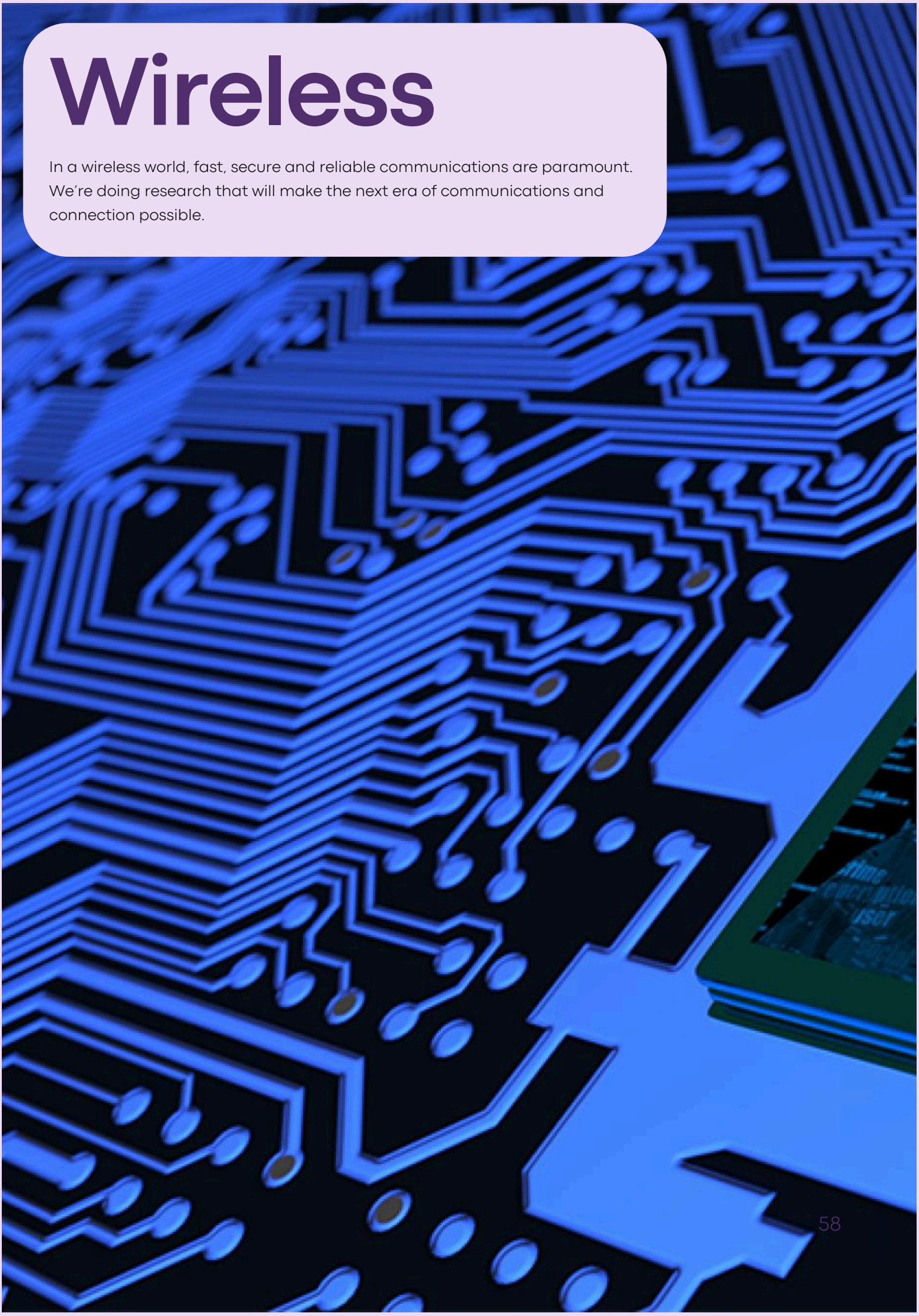
Acknowledgements

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

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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.



Using Reproducible Research to Teach Network Security

This project seeks to bridge the gap between coursework and research in the field of network security, by making it easier for students to engage with high-quality research artifacts. Experimental research in network security often involves artifacts, such as code and data sets, that should allow others to replicate the experiment. However, even when authors publicly share their artifacts, individuals new to the field may still find it difficult to use them. To address this, we re-package author-provided artifacts in the form of instructional materials that are suitable for students taking an introductory course on network security, and that run on an open-access testbed. These materials will be publicly shared to provide students with practical experience in network security topics, and to help them understand how research is conducted in this field.

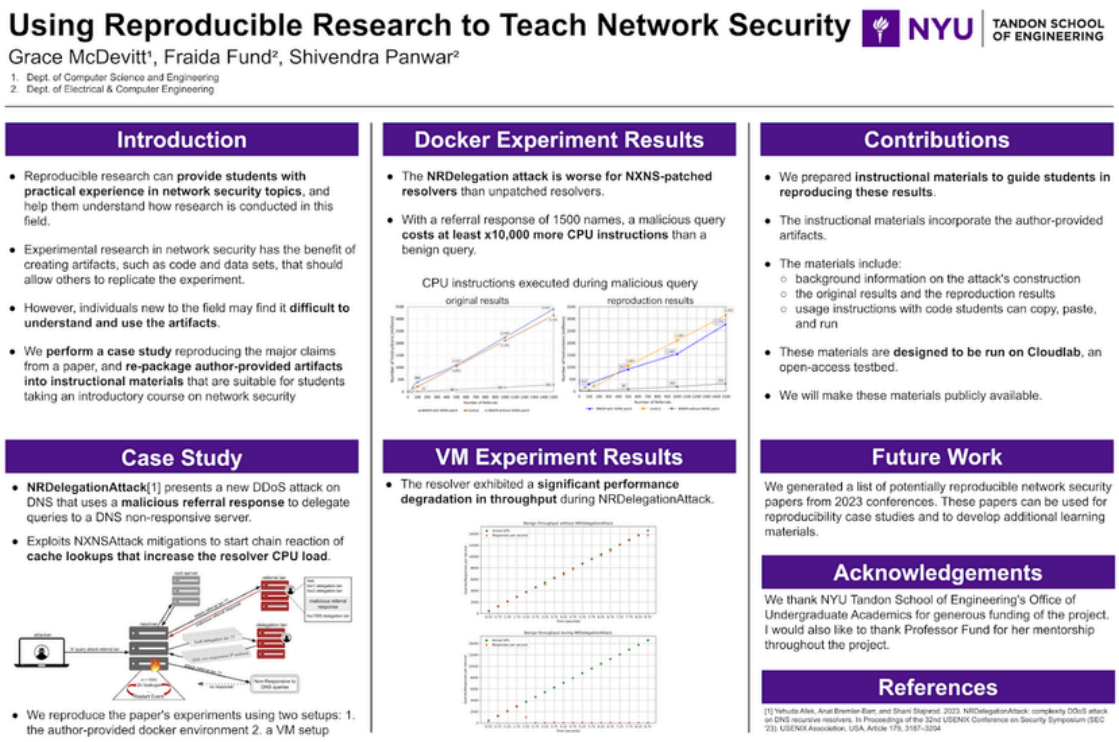
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Using Reproducible Research to Teach Network Security

NYU TANDON SCHOOL OF ENGINEERING

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2. Dept. of Electrical & Computer Engineering

Introduction

- Reproducible research can **provide students with practical experience in network security topics**, and help them understand how research is conducted in this field.
- Experimental research in network security has the benefit of creating artifacts, such as code and data sets, that should allow others to replicate the experiment.
- However, individuals new to the field may find it **difficult to understand and use the artifacts**.
- We **perform a case study** reproducing the major claims from a paper, and **re-package author-provided artifacts into instructional materials** that are suitable for students taking an introductory course on network security

Docker Experiment Results

- The **NRDelegation attack is worse for NXNS-patched resolvers** than unpatched resolvers.
- With a referral response of 1500 names, a malicious query **costs at least x10,000 more CPU instructions** than a benign query.

CPU instructions executed during malicious query

original results | reproduction results

Contributions

- We prepared **instructional materials to guide students in reproducing these results**.
- The instructional materials incorporate the author-provided artifacts.
- The materials include:
  - background information on the attack's construction
  - the original results and the reproduction results
  - usage instructions with code students can copy, paste, and run
- These materials are **designed to be run on Cloudlab**, an open-access testbed.
- We will make these materials publicly available.

Case Study

- **NRDelegationAttack**[1] presents a new DDoS attack on DNS that uses a **malicious referral response** to delegate queries to a DNS non-responsive server.
- Exploits NXNSAttack mitigations to start chain reaction of **cache lookups that increase the resolver CPU load**.
- We reproduce the paper's experiments using two setups: 1. the author-provided docker environment 2. a VM setup

VM Experiment Results

- The resolver exhibited a **significant performance degradation in throughput** during NRDelegationAttack.

Future Work

We generated a list of potentially reproducible network security papers from 2023 conferences. These papers can be used for reproducibility case studies and to develop additional learning materials.

Acknowledgements

We thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. I would also like to thank Professor Fund for her mentorship throughout the project.

References

[1] Yehuda Afek, Anat Bremler-Barr, and Shani Stajnrod. 2023. NRDelegationAttack: complexity DDoS attack on DNS recursive resolvers. In Proceedings of the 32nd USENIX Conference on Security Symposium (SEC '23). USENIX Association, USA, Article 175, 3187–3204

Realtime Network Quality-of-Service (QoS) Measurement and Prediction

With the exponential growth of mobile internet traffic and the increasing reliance on high-bandwidth applications such as video streaming, video conferencing, and online gaming, predicting future bandwidth availability is crucial for enhancing user Quality of Experience (QoE). This research extends previous work on bandwidth prediction by comparing Long Short-Term Memory (LSTM) neural networks with the TimesFM model and transformer models, utilizing newly collected 5G data. We conducted a comprehensive data collection campaign using Iperf to gather 5G bandwidth traces in various mobile scenarios, including subway and bus routes. The collected data was used to train and evaluate LSTM, TimesFM, and transformer models, with performance assessed based on Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) metrics. Our results reveal that the LSTM model consistently achieves the lowest RMSE and MAE across all tested scenarios, demonstrating superior prediction accuracy. Despite the promise of novel models such as TimesFM and transformers, LSTM neural networks remain the most accurate for mobile bandwidth prediction. Future research should explore hybrid models and incorporate additional contextual data, such as GPS and signal strength, to further enhance prediction accuracy and adapt to the evolving landscape of mobile internet traffic.

Project Supervisor Yong Liu

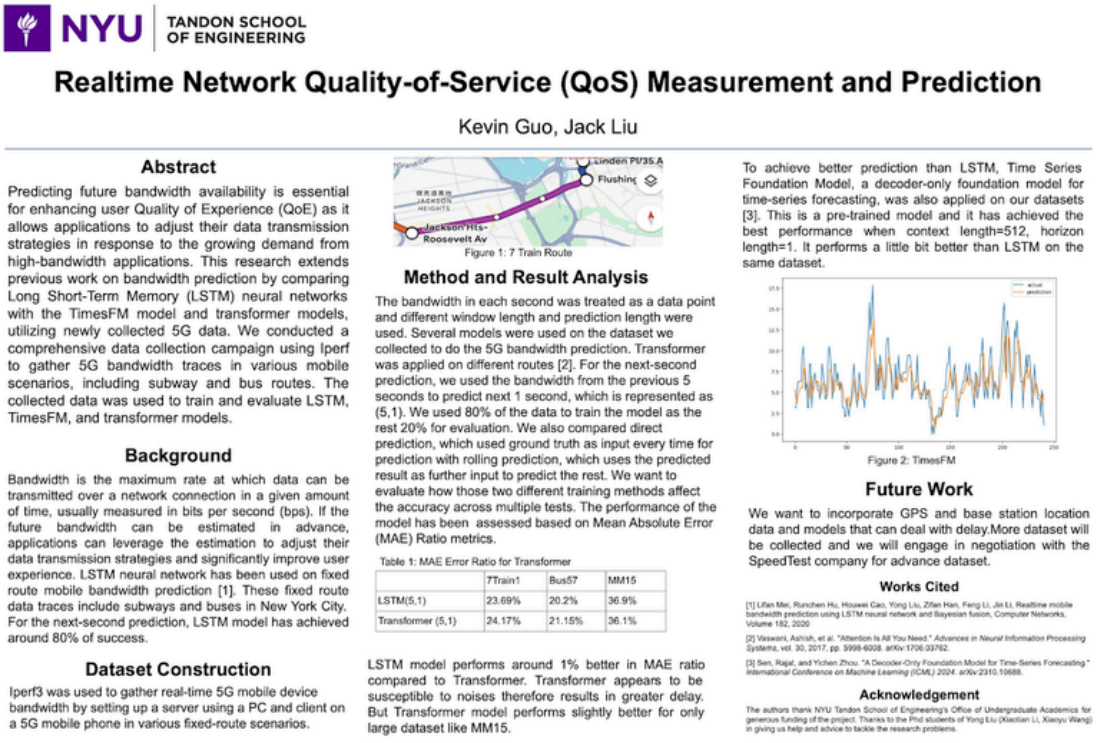
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NYU TANDON SCHOOL OF ENGINEERING

Realtime Network Quality-of-Service (QoS) Measurement and Prediction

Kevin Guo, Jack Liu

Abstract

Predicting future bandwidth availability is essential for enhancing user Quality of Experience (QoE) as it allows applications to adjust their data transmission strategies in response to the growing demand from high-bandwidth applications. This research extends previous work on bandwidth prediction by comparing Long Short-Term Memory (LSTM) neural networks with the TimesFM model and transformer models, utilizing newly collected 5G data. We conducted a comprehensive data collection campaign using Iperf to gather 5G bandwidth traces in various mobile scenarios, including subway and bus routes. The collected data was used to train and evaluate LSTM, TimesFM, and transformer models.

Background

Bandwidth is the maximum rate at which data can be transmitted over a network connection in a given amount of time, usually measured in bits per second (bps). If the future bandwidth can be estimated in advance, applications can leverage the estimation to adjust their data transmission strategies and significantly improve user experience. LSTM neural network has been used on fixed route mobile bandwidth prediction [1]. These fixed route data traces include subways and buses in New York City. For the next-second prediction, LSTM model has achieved around 80% of success.

Dataset Construction

Iperf3 was used to gather real-time 5G mobile device bandwidth by setting up a server using a PC and client on a 5G mobile phone in various fixed-route scenarios.

Figure 1: 7 Train Route

Method and Result Analysis

The bandwidth in each second was treated as a data point and different window length and prediction length were used. Several models were used on the dataset we collected to do the 5G bandwidth prediction. Transformer was applied on different routes [2]. For the next-second prediction, we used the bandwidth from the previous 5 seconds to predict next 1 second, which is represented as (5,1). We used 80% of the data to train the model as the rest 20% for evaluation. We also compared direct prediction, which used ground truth as input every time for prediction with rolling prediction, which uses the predicted result as further input to predict the rest. We want to evaluate how those two different training methods affect the accuracy across multiple tests. The performance of the model has been assessed based on Mean Absolute Error (MAE) Ratio metrics.

Table 1: MAE Error Ratio for Transformer

	7Train1	Bus57	MM15
LSTM(5,1)	23.69%	20.2%	36.9%
Transformer (5,1)	24.17%	21.15%	36.1%

LSTM model performs around 1% better in MAE ratio compared to Transformer. Transformer appears to be susceptible to noises therefore results in greater delay. But Transformer model performs slightly better for only large dataset like MM15.

To achieve better prediction than LSTM, Time Series Foundation Model, a decoder-only foundation model for time-series forecasting, was also applied on our datasets [3]. This is a pre-trained model and it has achieved the best performance when context length=512, horizon length=1. It performs a little bit better than LSTM on the same dataset.

Figure 2: TimesFM

Future Work

We want to incorporate GPS and base station location data and models that can deal with delay.More dataset will be collected and we will engage in negotiation with the SpeedTest company for advance dataset.

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[2] Vaswani, Ashish, et al. "Attention Is All You Need." Advances in Neural Information Processing Systems, vol. 30, 2017, pp. 5998-6008. arXiv:1706.03762.

[3] Sen, Rajat, and Yichen Zhou. "A Decoder-Only Foundation Model for Time-Series Forecasting." International Conference on Machine Learning (ICML) 2024. arXiv:2310.10688.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks to the Phd students of Yong Liu (Xiaotian Li, Xiaoyu Wang) in giving us help and advice to tackle the research problems.

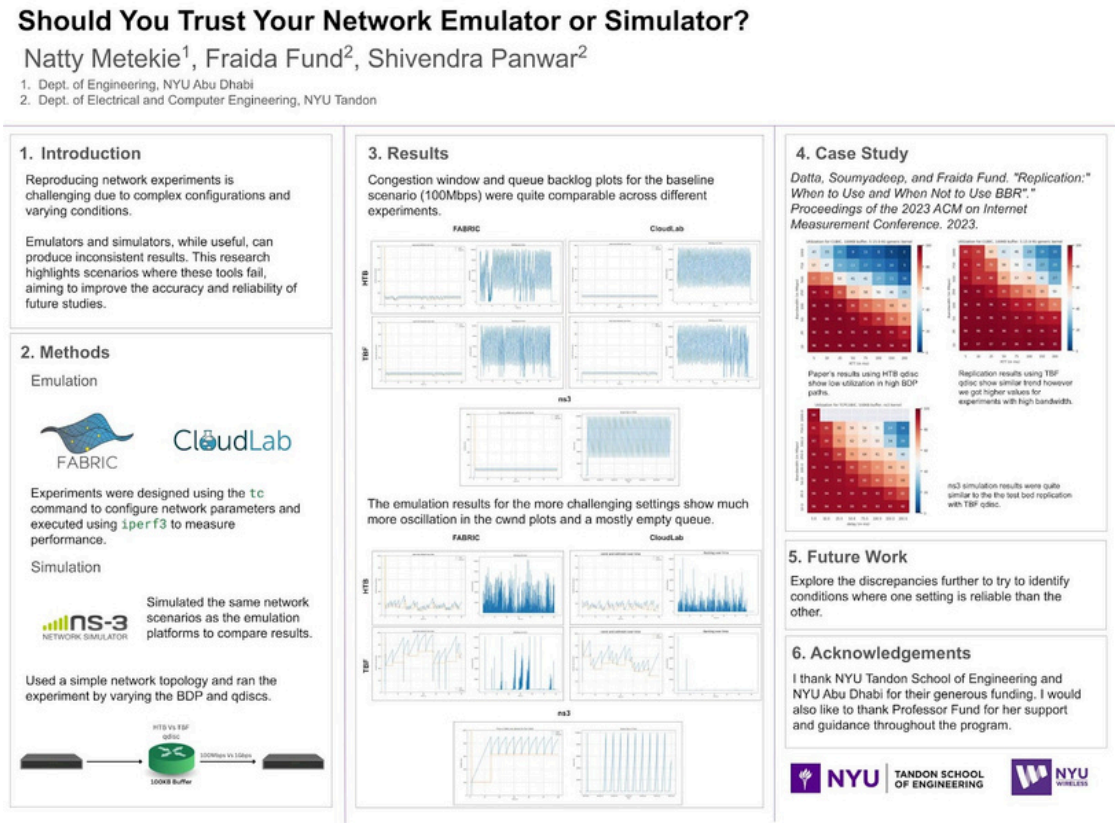
Should You Trust Your Network Emulator or Simulator?

Experimental research in computer networks often uses network emulation or simulation to recreate specific network settings in a controlled environment, such as a testbed. However, certain settings of widely used network emulation and simulation tools can cause incorrect behavior and inconsistent experimental results, potentially yielding contradictory outcomes for the same hypothesis depending on the tool that is used. This often goes unnoticed, as researchers typically use one approach and do not validate their results using different methods. Our research addresses this issue by identifying and demonstrating (on the FABRIC and CloudLab testbeds, and the ns-3 network simulation platform) specific scenarios where some research tools behave in incorrect or unexpected ways. Then, as case studies, we reproduce selected published results using different methodologies, and show that we would draw different conclusions depending on the approach that is used. Ultimately, our research seeks to provide insights that can guide the selection of tools and methodologies to enhance the accuracy and consistency of future studies in the field.

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Detection of Hidden 4G/5G Tracking Devices

The detection of hidden GPS (global positioning system) trackers operating on 4G LTE networks aims to help victims of cyberstalking and IPS (intimate partner surveillance). This research utilizes a tinySA, an affordable, handheld spectrum analyzer, to detect GPS tracker signals and establish quantitative detection parameters. Through monitoring the uplink frequency of the cellular band on which the tracker is operating using the tinySA, we are able to see spikes in the signal levels when the tracker is turned on or moving. To determine the correlation between distance from the tracker to the tinySA, we conducted an experiment where we incremented the distance in a controlled environment and measured the highest peaks in the signal. This also provides a threshold to determine how close the tracker needs to be to the user for it to be reliably detected. This data will inform the creation of a GUI (graphical user interface) to guide users through the detection process. This research combines the tinySA's technical capabilities with user-friendly design, empowering individuals to safeguard their privacy.

Project Supervisor Danny Yuxing Huang

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NYU TANDON SCHOOL OF ENGINEERING

Detection of 4G LTE Hidden Tracking Devices

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1. Washington University in St. Louis 2. Columbia University 3. New York University

Abstract

This research aims to help victims of cyberstalking and intimate partner surveillance by detecting hidden GPS trackers operating on 4G LTE networks. Using the tinySA, an affordable handheld spectrum analyzer, we monitor the uplink frequency of the cellular band to detect GPS tracker signals. Spikes in signal levels indicate the tracker's activation or movement. By incrementally increasing the distance between the tracker and the tinySA in a controlled experiment, we establish detection thresholds.

Background

Cyberstalking and intimate partner surveillance (IPS) are serious and growing problems, with approximately 3.4 million Americans victimized in 2019 alone, according to the U.S. Justice Department. Of these victims, 80% experienced attacks involving technology, and over 14% involved tracking software or hardware [1], leading to devastating consequences, including violence. Our research addresses this issue by focusing on detecting hidden GPS tracking devices operating on 4G LTE networks.

Works Cited
[1] Morgan, Rachel E., et al. "Stalking Victimization, 2019." Bureau of Justice Statistics, Feb. 2022.

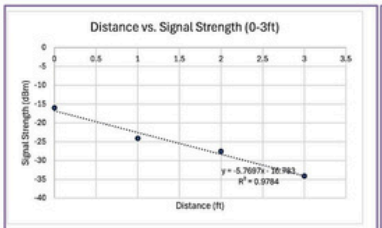


Figure 1: Distance vs. Signal Strength (0-3 ft)

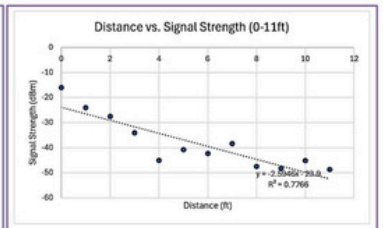


Figure 2: Distance vs. Signal Strength (0-11 ft)

Methodology

The tinySA was used to detect GPS tracker signals. By determining the cellular band the tracker operates on and setting the tinySA to the corresponding frequency, the uplink frequency was monitored for spikes in signal levels caused by the tracker's activation or movement. Through an experiment incrementally increasing the distance between the tinySA and the GPS tracker, the highest signal peaks were measured at each distance.

Acknowledgements
The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project along with Danny Huang and the research team at NYU mLab.

Conclusion

This research established a threshold, showing that the tinySA can detect the tracker up to three feet away. The data shows a stronger linear correlation between distance and signal strength from 0-3 ft (Figure 1) as compared to 0-11 ft (Figure 2).

Future Work

This data will inform the development of a graphical user interface (GUI) to guide users through the detection process, combining the tinySA's technical capabilities with a user-friendly design.

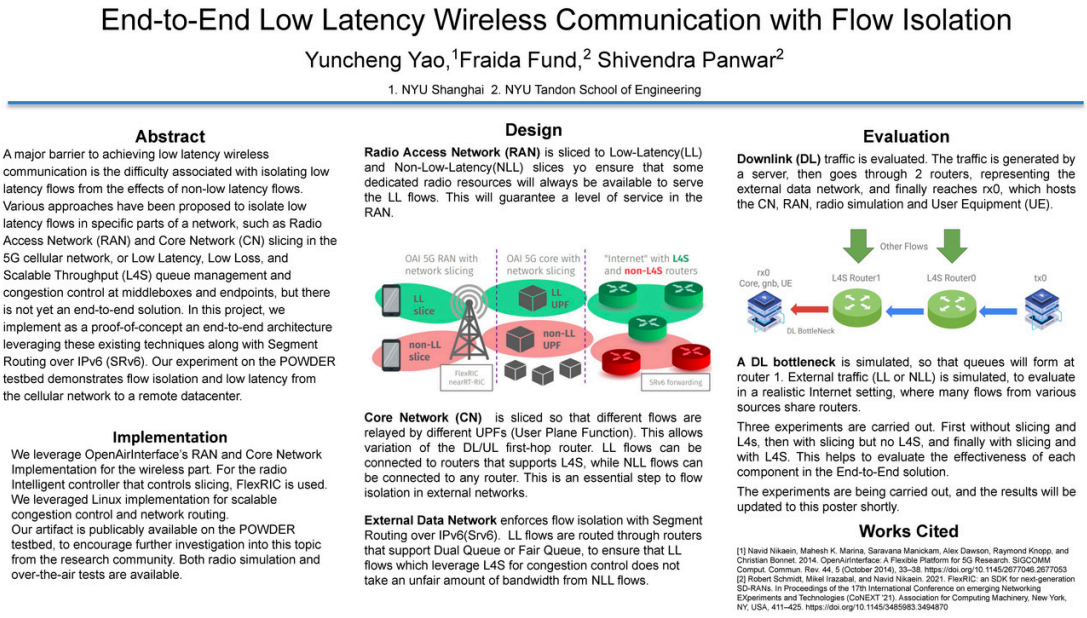
End-to-End Low Latency Wireless Communication with Flow Isolation

A major barrier to achieving low latency wireless communication is the difficulty associated with isolating low latency flows from the effects of non-low latency flows. Various approaches have been proposed to isolate low latency flows in specific parts of a network, such as Radio Access Network (RAN) and Core Network (CN) slicing in the 5G cellular network, or Low Latency, Low Loss, and Scalable Throughput (L4S) queue management and congestion control at middleboxes and endpoints, but there is not yet an end-to-end solution. In this project, we implement as a proof-of-concept an end-to-end architecture leveraging these existing techniques along with Segment Routing over IPv6 (SRv6). Our experiment on the POWDER testbed demonstrates flow isolation and low latency from the cellular network to a remote datacenter. We make all artifacts necessary to reproduce our experiment publicly available, to encourage further development of this idea and improve latency performance in 5G wireless networks.

Project Supervisor Shivendra Panwar
Research Areas Wireless
Research Staff Fraida Fund



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End-to-End Low Latency Wireless Communication with Flow Isolation

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1. NYU Shanghai 2. NYU Tandon School of Engineering

Abstract

A major barrier to achieving low latency wireless communication is the difficulty associated with isolating low latency flows from the effects of non-low latency flows. Various approaches have been proposed to isolate low latency flows in specific parts of a network, such as Radio Access Network (RAN) and Core Network (CN) slicing in the 5G cellular network, or Low Latency, Low Loss, and Scalable Throughput (L4S) queue management and congestion control at middleboxes and endpoints, but there is not yet an end-to-end solution. In this project, we implement as a proof-of-concept an end-to-end architecture leveraging these existing techniques along with Segment Routing over IPv6 (SRv6). Our experiment on the POWDER testbed demonstrates flow isolation and low latency from the cellular network to a remote datacenter.

Implementation

We leverage OpenAirInterface's RAN and Core Network Implementation for the wireless part. For the radio Intelligent controller that controls slicing, FlexRIC is used. We leveraged Linux implementation for scalable congestion control and network routing.
Our artifact is publicly available on the POWDER testbed, to encourage further investigation into this topic from the research community. Both radio simulation and over-the-air tests are available.

Design

Radio Access Network (RAN) is sliced to Low-Latency(LL) and Non-Low-Latency(NLL) slices yo ensure that some dedicated radio resources will always be available to serve the LL flows. This will guarantee a level of service in the RAN.

Core Network (CN) is sliced so that different flows are relayed by different UPFs (User Plane Function). This allows variation of the DL/UL first-hop router. LL flows can be connected to routers that supports L4S, while NLL flows can be connected to any router. This is an essential step to flow isolation in external networks.

External Data Network enforces flow isolation with Segment Routing over IPv6(Srv6). LL flows are routed through routers that support Dual Queue or Fair Queue, to ensure that LL flows which leverage L4S for congestion control does not take an unfair amount of bandwidth from NLL flows.

Evaluation

Downlink (DL) traffic is evaluated. The traffic is generated by a server, then goes through 2 routers, representing the external data network, and finally reaches rx0, which hosts the CN, RAN, radio simulation and User Equipment (UE).

A DL bottleneck is simulated, so that queues will form at router 1. External traffic (LL or NLL) is simulated, to evaluate in a realistic Internet setting, where many flows from various sources share routers.

Three experiments are carried out. First without slicing and L4s, then with slicing but no L4S, and finally with slicing and with L4S. This helps to evaluate the effectiveness of each component in the End-to-End solution.

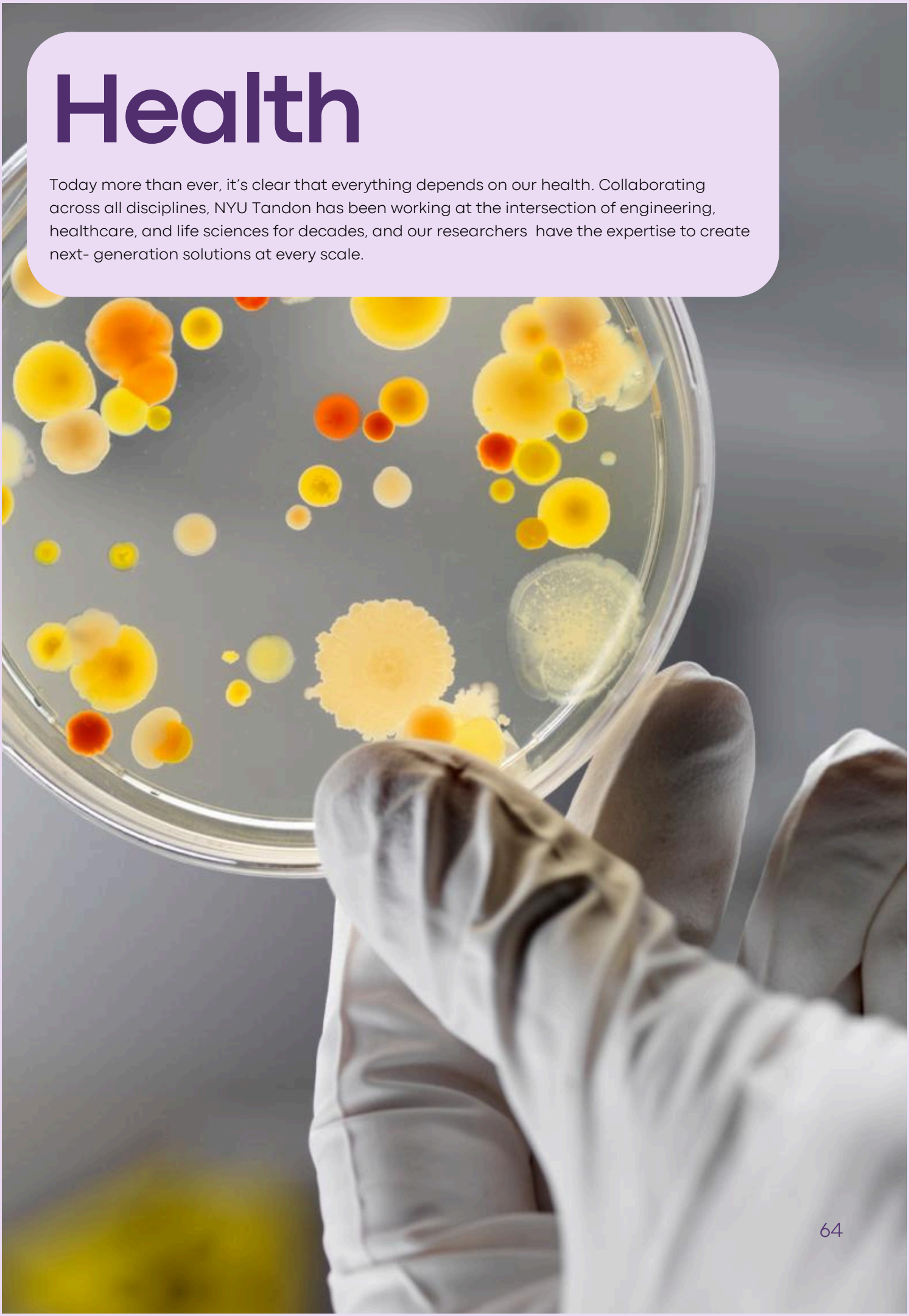
The experiments are being carried out, and the results will be updated to this poster shortly.

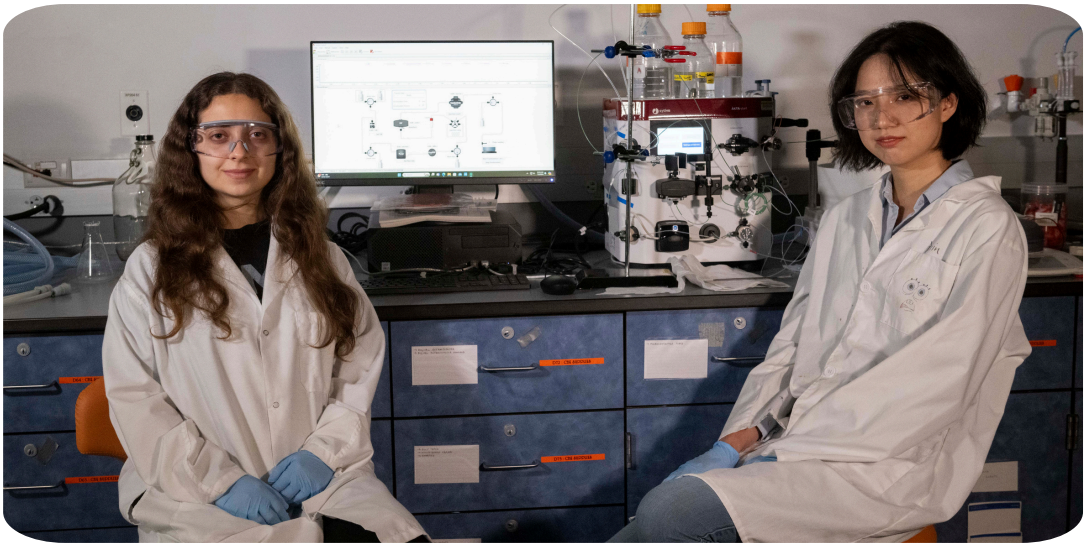
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Health

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.





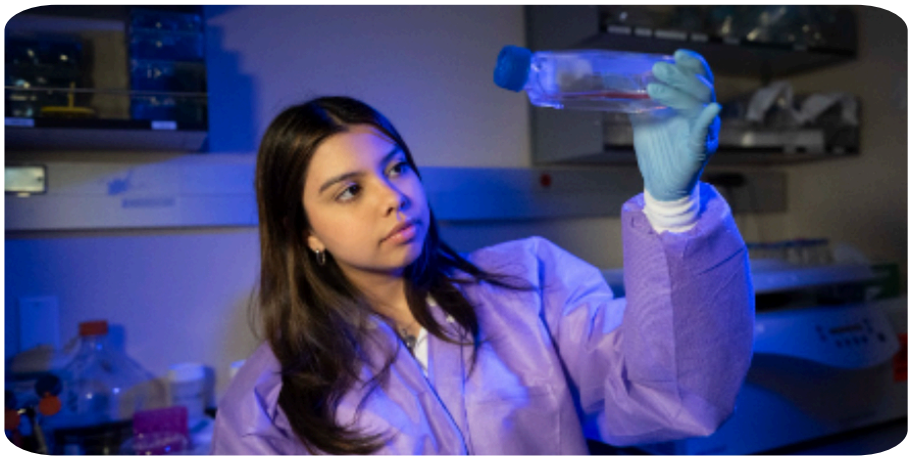
Dania Muhieddine Orfali (left) and Yaxin Shen (Right)

Dania and Yaxin working on protein separation via HPLC for 4 different proteins. The project is to develop and test an experiment for CBE undergraduate capstone project.



Terry Mu

Wrote runtime and VOC detection routines for the Jetson Orin Nano robot equipped with the SGP-40.



Ana Negrin Sanchez

Ana is observing a cell flask containing culture cardyomyocytes after observing them on the microscope

CRISPR/Cas9-mediated Tagging of TUBB3 with Red Flourescent Protein to Investigate Its Role in Cancer Cell Dynamics

The TUBB3 gene, or Tubulin Beta-3 Chain, is crucial for the development of the central and peripheral nervous systems and serves as a marker of neuronal differentiation. Its elevated expression is associated with various cancers, particularly neurogenic tumors, highlighting its importance in cancer research. This study utilizes CRISPR/Cas9 genome editing technology to integrate a Red Fluorescent Protein (RFP) tag into the TUBB3 gene within cancer cell lines, enabling the visualization of TUBB3 gene activity and providing insights into its role in cancer progression. Guide RNAs targeting the TUBB3 coding region were designed and transfected into cancer cells along with donor DNA and Cas9 nuclease. The donor DNA was engineered to include a 2A self-cleaving peptide to preserve the natural folding and localization of the TUBB3 protein, maintaining its native function. The gene editing process utilized Homology-Directed Repair (HDR) and was followed by PCR amplification with custom-designed homology arm primers and Phusion™ Flash High Fidelity PCR Master Mix to ensure accuracy and minimize errors. The successful incorporation of the RFP tag was confirmed through fluorescence microscopy and genome sequencing. The Illumina DNA Prep Protocol and iSeq 00 platform were employed for high-throughput sequencing of the edited genomic regions, involving tagmentation, post-tagmentation cleanup, amplification, and library preparation. This research provides a novel method for tracking TUBB3 activity in cancer cells, offering valuable insights into its role in oncogenesis and establishing a foundation for developing targeted therapies.

Project Supervisor Nikita Grigoryev

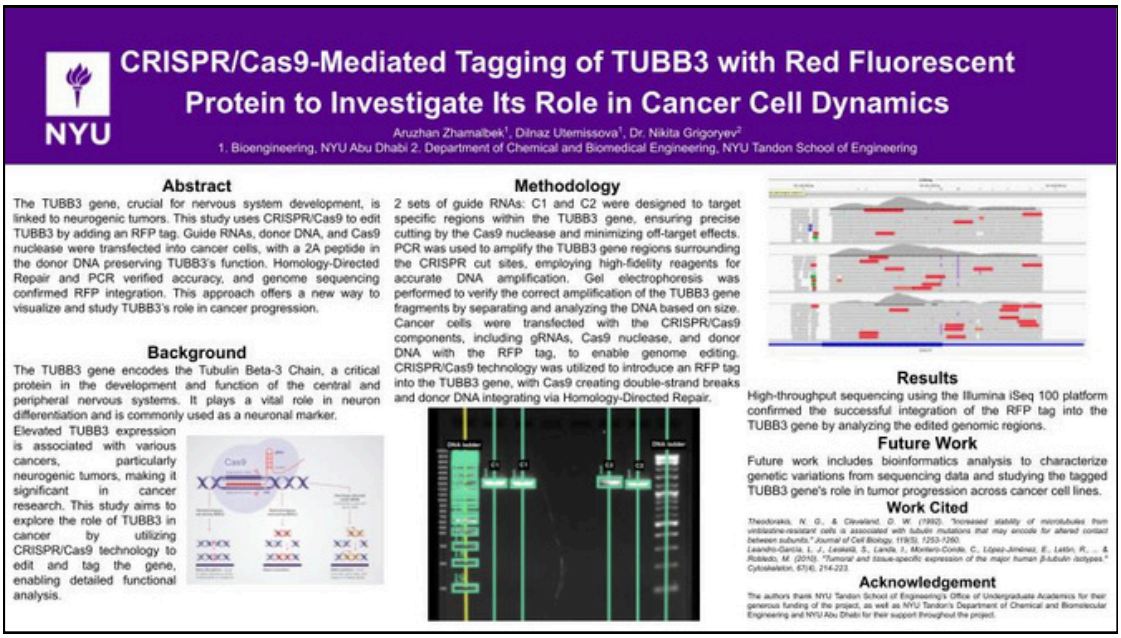
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CRISPR/Cas9-Mediated Tagging of TUBB3 with Red Fluorescent Protein to Investigate Its Role in Cancer Cell Dynamics

NYU

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Abstract

The TUBB3 gene, crucial for nervous system development, is linked to neurogenic tumors. This study uses CRISPR/Cas9 to edit TUBB3 by adding an RFP tag. Guide RNAs, donor DNA, and Cas9 nuclease were transfected into cancer cells, with a 2A peptide in the donor DNA preserving TUBB3's function. Homology-Directed Repair and PCR verified accuracy, and genome sequencing confirmed RFP integration. This approach offers a new way to visualize and study TUBB3's role in cancer progression.

Background

The TUBB3 gene encodes the Tubulin Beta-3 Chain, a critical protein in the development and function of the central and peripheral nervous systems. It plays a vital role in neuron differentiation and is commonly used as a neuronal marker. Elevated TUBB3 expression is associated with various cancers, particularly neurogenic tumors, making it significant in cancer research. This study aims to explore the role of TUBB3 in cancer by utilizing CRISPR/Cas9 technology to edit and tag the gene, enabling detailed functional analysis.

Methodology

2 sets of guide RNAs: C1 and C2 were designed to target specific regions within the TUBB3 gene, ensuring precise cutting by the Cas9 nuclease and minimizing off-target effects. PCR was used to amplify the TUBB3 gene regions surrounding the CRISPR cut sites, employing high-fidelity reagents for accurate DNA amplification. Gel electrophoresis was performed to verify the correct amplification of the TUBB3 gene fragments by separating and analyzing the DNA based on size. Cancer cells were transfected with the CRISPR/Cas9 components, including gRNAs, Cas9 nuclease, and donor DNA with the RFP tag, to enable genome editing. CRISPR/Cas9 technology was utilized to introduce an RFP tag into the TUBB3 gene, with Cas9 creating double-strand breaks and donor DNA integrating via Homology-Directed Repair.

Results

High-throughput sequencing using the Illumina iSeq 100 platform confirmed the successful integration of the RFP tag into the TUBB3 gene by analyzing the edited genomic regions.

Future Work

Future work includes bioinformatics analysis to characterize genetic variations from sequencing data and studying the tagged TUBB3 gene's role in tumor progression across cancer cell lines.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for their generous funding of the project, as well as NYU Tandon's Department of Chemical and Biomolecular Engineering and NYU Abu Dhabi for their support throughout the project.

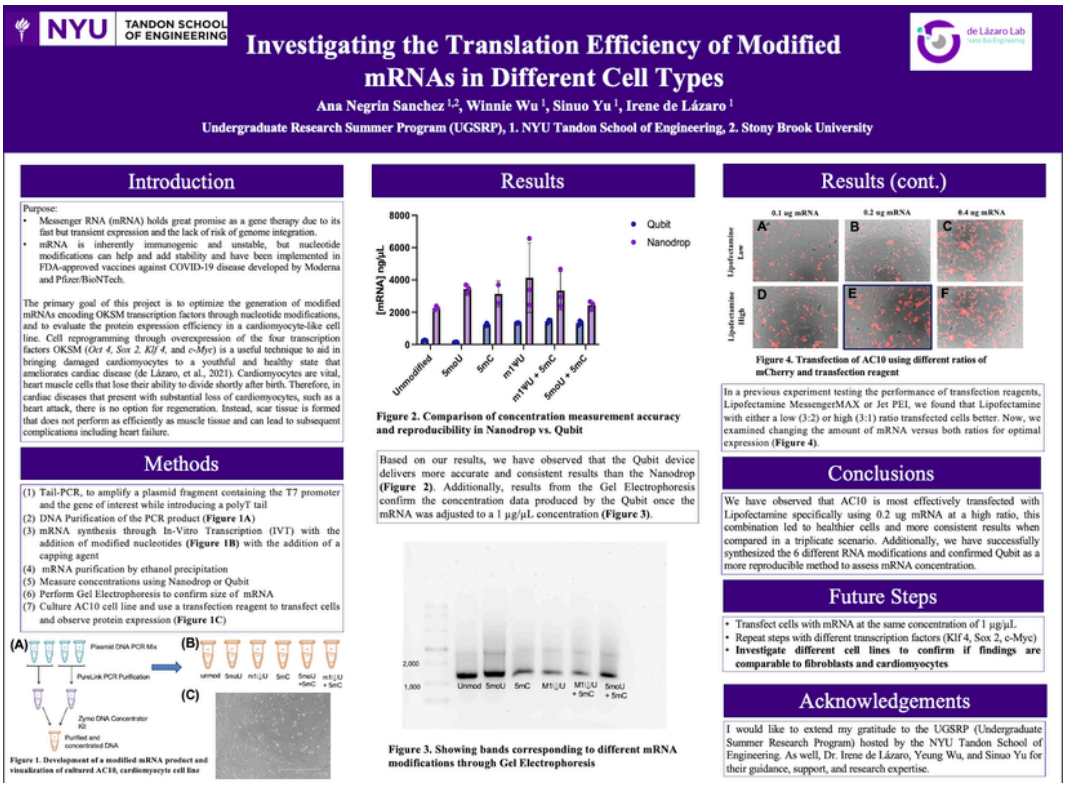
Investigating the Translation Efficiency of Modified mRNAs in Different Cell Types

Cardiomyocytes are vital, heart muscle cells that lose their ability to divide shortly after birth. Therefore, in cardiac diseases that present with substantial loss of cardiomyocytes, such as a heart attack, there is no option for regeneration. Instead, scar tissue is formed that does not perform as efficiently as muscle tissue and can lead to subsequent complications including heart failure. Cell reprogramming through overexpression of the four transcription factors OKSM (Oct 4, Sox 2, Klf 4, and c-Myc) is a useful technique to aid in bringing damaged cardiomyocytes to a youthful and healthy state that ameliorates cardiac disease (de Lázaro et. al 2021). The primary goal of this project is to optimize the generation of modified mRNAs encoding OKSM transcription factors through nucleotide modifications, and to evaluate the protein expression efficiency in a cardiomyocyte-like cell line. mRNA synthesis was performed following these steps: (1) Tail-PCR, to amplify a plasmid fragment containing the T7 promoter and the gene of interest while introducing a polyT tail; (2) purification of the PCR product; (3) mRNA synthesis through In-Vitro Transcription with the addition of a capping agent and (4) mRNA purification by ethanol precipitation. The specific nucleotide modifications screened for Oct 4 overexpression were: 5moU (5-methoxyluridine), m1ΨU (1-methylpsuedouridine), 5mC (5-methylcystosine), and the combinations of 5moU + 5mC, and m1ΨU + 5mC. These modified Oct 4 mRNAs and their unmodified counterparts were delivered into a cardiomyocyte-like cell line (AC) using the transfection reagent Lipofectamine in order to assess differences in translation efficiency. Previously, transfection conditions had been optimized with an mRNA encoding for the fluorescent protein mCherry.

Project Supervisor Irene de Lazaro
Research Areas Health
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CRISPR/Cas9 Technology for Visualizing REST Expression in Glioblastoma

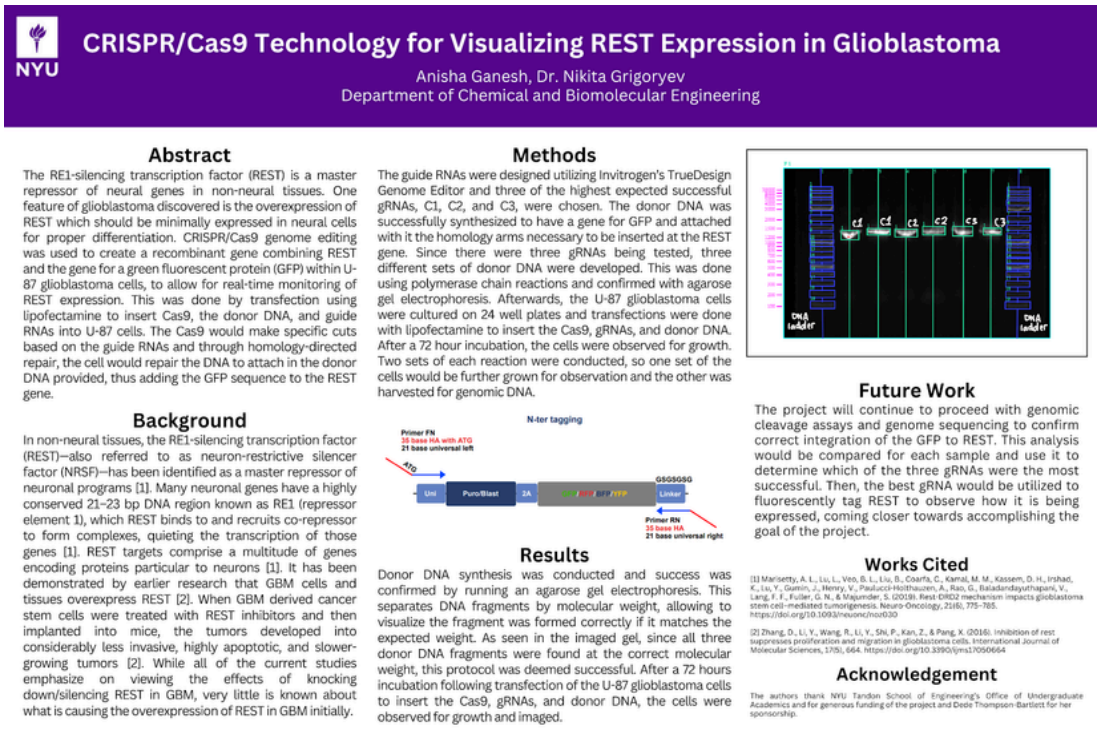
Glioblastoma multiforme (GBM) accounts for up to 50% of all primary brain gliomas in adults and is one of the most prevalent and aggressive primary brain tumors. One feature of glioblastoma discovered is the overexpression of a protein named RE1-silencing transcription factor (REST). REST essentially is a protein that targets specifically neuronal genes and prevents their expression in non-neural tissues. However, in neural cells, it is very minimally expressed in order to allow the cells to properly differentiate into neural cells. Therefore, the overexpression of REST in glioblastoma could be a contributing factor of the cancer progression, but current literature doesn't provide an explanation for the cause of the overexpression observed. This project aimed at using CRISPR/Cas9 technology to visualize REST expression to formulate a reason for its overexpression. Donor DNA, a piece of DNA that would be attached to the REST gene, was designed to include the sequence for a green fluorescent protein (GFP). Then, transfection using lipofectamine was conducted to insert Cas9, the donor DNA, and guide RNAs into U-87 glioblastoma cells. The Cas9 would make specific cuts based on the guide RNAs and through homology-directed repair, the cell would repair the DNA to attach in the donor DNA provided, thus adding the GFP sequence to the REST gene. The guide RNAs were designed utilizing Invitrogen's TrueTag Genome Editor and three of the highest expected successful gRNAs were chosen. The actual success between these three gRNAs would be measured in comparison to control cells through genomic cleavage assays and genome sequencing. The results of this research would establish the ideal parameters to successfully incorporate the GFP tag to the REST gene through CRISPR/Cas9. This would allow for future research to be able to visualize the expression of REST and work towards forming an understanding of the reason for its overexpression.

Project Supervisor Nikita Grigoryev

Research Areas Health



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Thompson-Bartlett Fellowship



NYU

CRISPR/Cas9 Technology for Visualizing REST Expression in Glioblastoma

Anisha Ganesh, Dr. Nikita Grigoryev
Department of Chemical and Biomolecular Engineering

Abstract

The RE1-silencing transcription factor (REST) is a master repressor of neural genes in non-neural tissues. One feature of glioblastoma discovered is the overexpression of REST which should be minimally expressed in neural cells for proper differentiation. CRISPR/Cas9 genome editing was used to create a recombinant gene combining REST and the gene for a green fluorescent protein (GFP) within U-87 glioblastoma cells, to allow for real-time monitoring of REST expression. This was done by transfection using lipofectamine to insert Cas9, the donor DNA, and guide RNAs into U-87 cells. The Cas9 would make specific cuts based on the guide RNAs and through homology-directed repair, the cell would repair the DNA to attach in the donor DNA provided, thus adding the GFP sequence to the REST gene.

Background

In non-neural tissues, the RE1-silencing transcription factor (REST)—also referred to as neuron-restrictive silencer factor (NRSF)—has been identified as a master repressor of neuronal programs [1]. Many neuronal genes have a highly conserved 21–23 bp DNA region known as RE1 (repressor element 1), which REST binds to and recruits co-repressor to form complexes, quieting the transcription of those genes [1]. REST targets comprise a multitude of genes encoding proteins particular to neurons [1]. It has been demonstrated by earlier research that GBM cells and tissues overexpress REST [2]. When GBM derived cancer stem cells were treated with REST inhibitors and then implanted into mice, the tumors developed into considerably less invasive, highly apoptotic, and slower-growing tumors [2]. While all of the current studies emphasize on viewing the effects of knocking down/silencing REST in GBM, very little is known about what is causing the overexpression of REST in GBM initially.

Methods

The guide RNAs were designed utilizing Invitrogen's TrueDesign Genome Editor and three of the highest expected successful gRNAs, C1, C2, and C3, were chosen. The donor DNA was successfully synthesized to have a gene for GFP and attached with it the homology arms necessary to be inserted at the REST gene. Since there were three gRNAs being tested, three different sets of donor DNA were developed. This was done using polymerase chain reactions and confirmed with agarose gel electrophoresis. Afterwards, the U-87 glioblastoma cells were cultured on 24 well plates and transfections were done with lipofectamine to insert the Cas9, gRNAs, and donor DNA. After a 72 hour incubation, the cells were observed for growth. Two sets of each reaction were conducted, so one set of the cells would be further grown for observation and the other was harvested for genomic DNA.

Results

Donor DNA synthesis was conducted and success was confirmed by running an agarose gel electrophoresis. This separates DNA fragments by molecular weight, allowing to visualize the fragment was formed correctly if it matches the expected weight. As seen in the imaged gel, since all three donor DNA fragments were found at the correct molecular weight, this protocol was deemed successful. After a 72 hours incubation following transfection of the U-87 glioblastoma cells to insert the Cas9, gRNAs, and donor DNA, the cells were observed for growth and imaged.

Future Work

The project will continue to proceed with genomic cleavage assays and genome sequencing to confirm correct integration of the GFP to REST. This analysis would be compared for each sample and use it to determine which of the three gRNAs were the most successful. Then, the best gRNA would be utilized to fluorescently tag REST to observe how it is being expressed, coming closer towards accomplishing the goal of the project.

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Studying laser-induced crystallization of urea in isopropanol

Non-photochemical laser-induced nucleation (NPLIN) is the process where nanosecond laser pulses trigger the formation of a new phase from a metastable phase in various supersaturated solutions. The mechanism by which NPLIN occurs is debated, as it is unknown why some systems undergo NPLIN, but others do not. NPLIN was first observed with urea in water, and this study aimed to provide a better understanding of NPLIN by using simple alcohol solvents. Presently, urea in isopropanol as a system is studied, drawing from preliminary experiments of urea in methanol. First, different supersaturation levels of urea in isopropanol were irradiated, and different methods of observation were used to make conclusions about NPLIN of urea in isopropanol in a batch process. Next, the system was fed through a microfluidic device, which reduce the effect of nucleation by mechanical shock compared to irradiating vials of urea in isopropanol. A novel video analysis program was consequently developed in Python in order to track and count crystals formed through NPLIN moving through the microfluidic device. This program allows for more rapid analysis of crystallization experiments in flow, and eventually can lead to live processing of these experiments. Studying NPLIN urea in isopropanol can help researchers better understand why certain systems undergo NPLIN, and ultimately can offer advantages in crystallization processes, such as in the pharmaceutical industry.

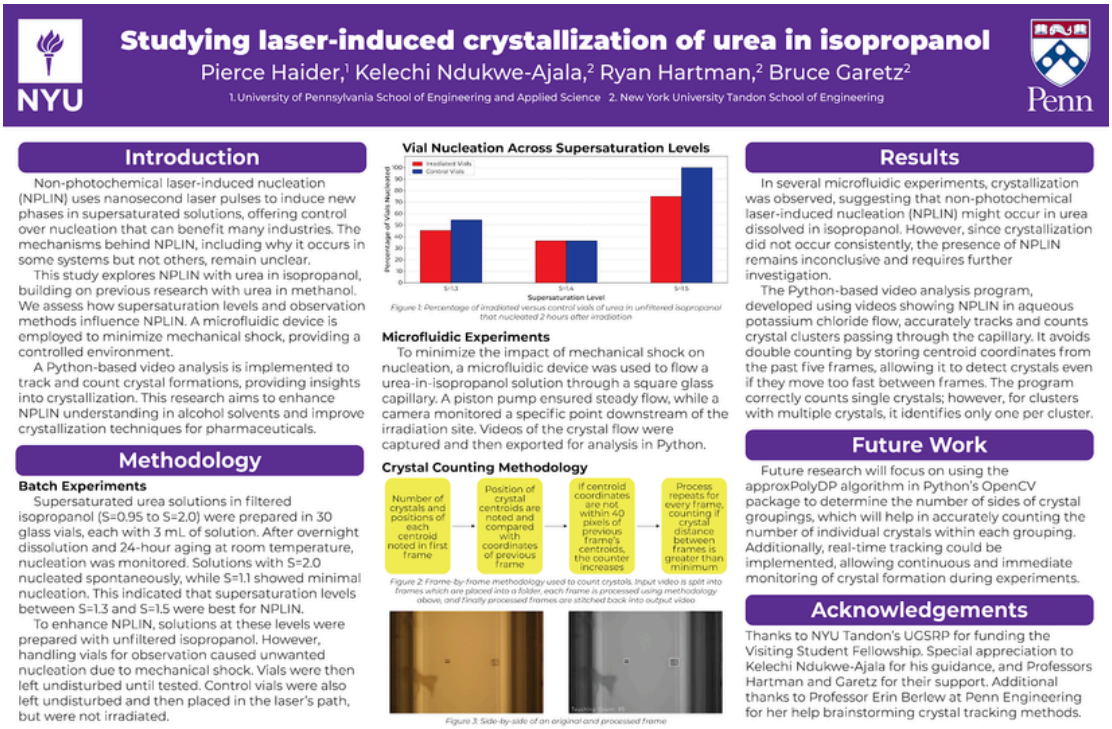
Project Supervisor Kelechi Ndukwe-Ajala

Research Areas Health

Research Staff Bruce Garetz, Ryan Hartman



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Studying laser-induced crystallization of urea in isopropanol

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1. University of Pennsylvania School of Engineering and Applied Science 2. New York University Tandon School of Engineering

Introduction

Non-photochemical laser-induced nucleation (NPLIN) uses nanosecond laser pulses to induce new phases in supersaturated solutions, offering control over nucleation that can benefit many industries. The mechanisms behind NPLIN, including why it occurs in some systems but not others, remain unclear.

This study explores NPLIN with urea in isopropanol, building on previous research with urea in methanol. We assess how supersaturation levels and observation methods influence NPLIN. A microfluidic device is employed to minimize mechanical shock, providing a controlled environment.

A Python-based video analysis is implemented to track and count crystal formations, providing insights into crystallization. This research aims to enhance NPLIN understanding in alcohol solvents and improve crystallization techniques for pharmaceuticals.

Methodology

Batch Experiments

Supersaturated urea solutions in filtered isopropanol (S=0.95 to S=2.0) were prepared in 30 glass vials, each with 3 mL of solution. After overnight dissolution and 24-hour aging at room temperature, nucleation was monitored. Solutions with S=2.0 nucleated spontaneously, while S=1.1 showed minimal nucleation. This indicated that supersaturation levels between S=1.3 and S=1.5 were best for NPLIN.

To enhance NPLIN, solutions at these levels were prepared with unfiltered isopropanol. However, handling vials for observation caused unwanted nucleation due to mechanical shock. Vials were then left undisturbed until tested. Control vials were also left undisturbed and then placed in the laser's path, but were not irradiated.

Vial Nucleation Across Supersaturation Levels

Figure 1: Percentage of irradiated versus control vials of urea in unfiltered isopropanol that nucleated 2 hours after irradiation

Microfluidic Experiments

To minimize the impact of mechanical shock on nucleation, a microfluidic device was used to flow a urea-in-isopropanol solution through a square glass capillary. A piston pump ensured steady flow, while a camera monitored a specific point downstream of the irradiation site. Videos of the crystal flow were captured and then exported for analysis in Python.

Crystal Counting Methodology

Figure 2: Frame-by-frame methodology used to count crystals. Input video is split into frames which are placed into a folder, each frame is processed using methodology above, and finally processed frames are stitched back into output video

Figure 3: Side-by-side of an original and processed frame

Results

In several microfluidic experiments, crystallization was observed, suggesting that non-photochemical laser-induced nucleation (NPLIN) might occur in urea dissolved in isopropanol. However, since crystallization did not occur consistently, the presence of NPLIN remains inconclusive and requires further investigation.

The Python-based video analysis program, developed using videos showing NPLIN in aqueous potassium chloride flow, accurately tracks and counts crystal clusters passing through the capillary. It avoids double counting by storing centroid coordinates from the past five frames, allowing it to detect crystals even if they move too fast between frames. The program correctly counts single crystals; however, for clusters with multiple crystals, it identifies only one per cluster.

Future Work

Future research will focus on using the approxPolyDP algorithm in Python's OpenCV package to determine the number of sides of crystal groupings, which will help in accurately counting the number of individual crystals within each grouping. Additionally, real-time tracking could be implemented, allowing continuous and immediate monitoring of crystal formation during experiments.

Acknowledgements

Thanks to NYU Tandon's UGSRP for funding the Visiting Student Fellowship. Special appreciation to Kelechi Ndukwe-Ajala for his guidance, and Professors Hartman and Garetz for their support. Additional thanks to Professor Erin Berlew at Penn Engineering for her help brainstorming crystal tracking methods.

The role of a RHAMM-mimetic peptide in Cartilage Repair

Cartilage damage often leads to pain due to the formation of fibrocartilage as opposed to hyaline cartilage during the repair process, resulting in the development of post-traumatic osteoarthritis after joint injury. Current approaches, including microfracture surgery and cell-based approaches, fail to prevent fibrocartilage formation, resulting in continued joint inflammation and pain. Fibrocartilage formation has been shown to result from a prolonged presence of pro-inflammatory M1 macrophages in the initial stage after cartilage injury. Pro-inflammatory M1 macrophage polarization is mediated by hyaluronan (HA) binding to the receptor for hyaluronan-mediated motility (RHAMM) and CD44. In this study, we employed P15-1 – a 15-residue RHAMM-mimetic peptide previously shown to bind HA– as well as a novel RHAMM-mimetic peptide to interfere with these interactions. We then assessed the extent to which these peptides reduced inflammation in both macrophages and synovial fibroblasts, which also contribute to fibrocartilage formation. Interactions between macrophages and synovial fibroblasts were analyzed as well. Additionally, extracellular CD44 cleavage has been hypothesized to be an indicator of inflammation. The soluble CD44 (sCD44) concentration was determined; however, there were no significant differences between M1 pro-inflammatory macrophages and M2 anti-inflammatory macrophages, suggesting that sCD44 is not a reliable indicator of inflammation. Moreover, P15-1 and the novel RHAMM-mimetic peptide both resulted in significantly reduced expression of several inflammatory markers, including IL-6 and MMP3, in both macrophages and synovial fibroblasts, as well as in macrophages treated with synovial fibroblast medium. These findings suggest that both P15-1 and the novel RHAMM-mimetic peptide may be used as therapeutics to reduce inflammation through the disruption of HA/RHAMM and HA/CD44 interactions, resulting in improved cartilage repair and prevention of post-traumatic osteoarthritis.

Project Supervisor Thorsten Kirsch

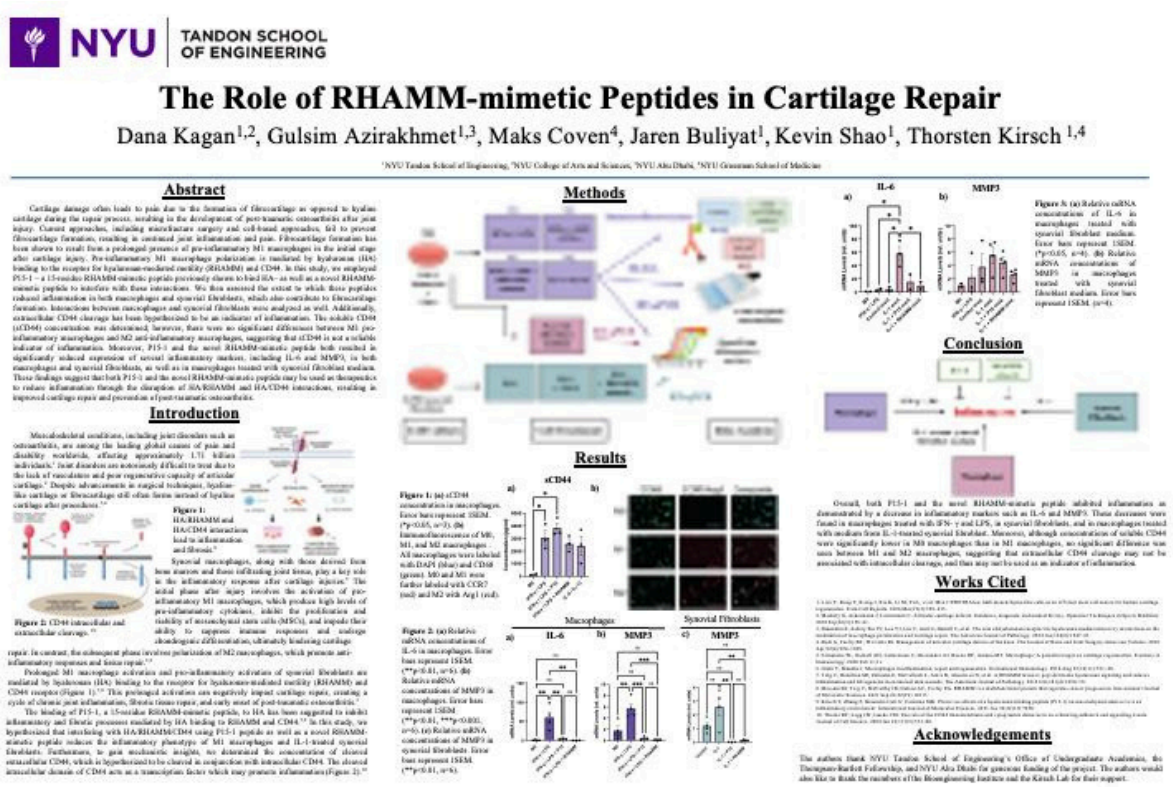
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NYU TANDON SCHOOL OF ENGINEERING

The Role of RHAMM-mimetic Peptides in Cartilage Repair

Dana Kagan[1,2], Gulsim Azirakhmet[1,3], Maks Coven[4], Jaren Buliyat[1], Kevin Shao[1], Thorsten Kirsch [1,4]

Abstract

Introduction

Methods

Results

Conclusion

Works Cited

Acknowledgements

Measuring Hair Cortisol Concentrations (HCC) in Myocardinal Infarction (MI) Patients and Teseting its Association with Anxiety

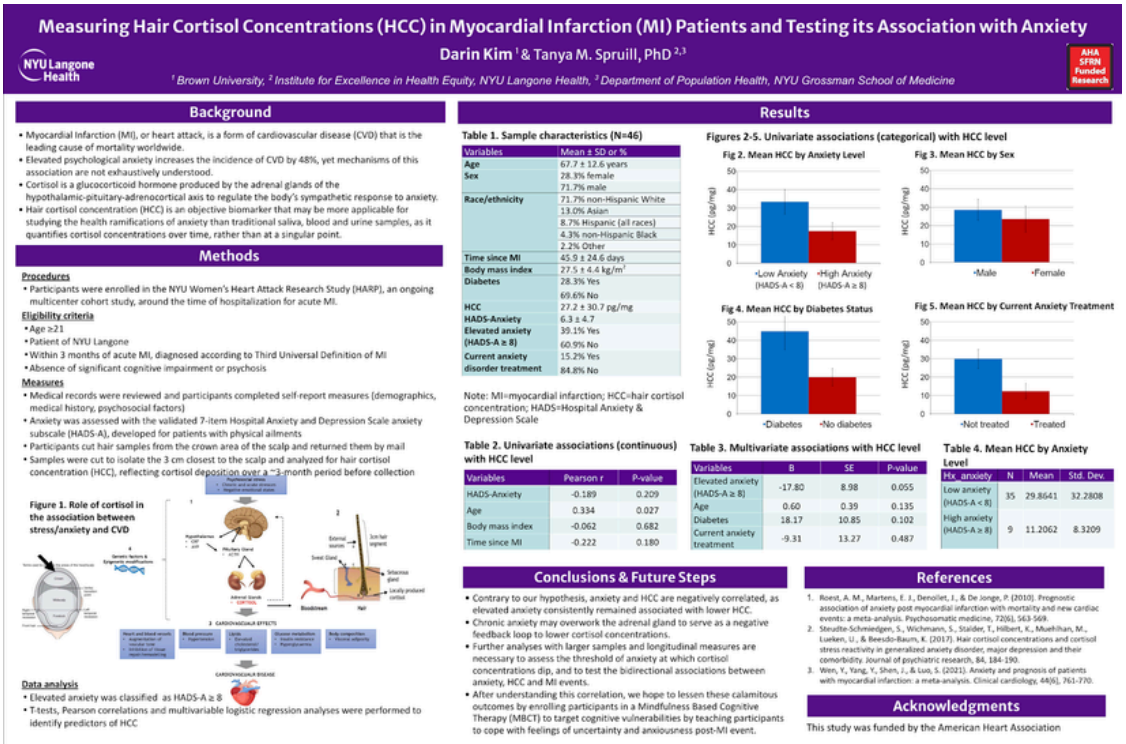
Myocardial Infarction (MI), or heart attack, is a form of cardiovascular disease (CVD) that is the leading cause of mortality worldwide. Elevated psychological anxiety increases the incidence of CVD by 48%, yet mechanisms of this association are not understood. Cortisol is a glucocorticoid hormone produced by the adrenal glands to regulate the body's stress response. Hair cortisol concentration (HCC) is an objective biomarker that may be more useful for studying health effects of anxiety than traditional saliva, blood and urine samples, as it quantifies cortisol concentrations over time, rather than at a singular point. This research examines the correlation between anxiety and HCC in post-MI patients. Men and women with recent MI completed baseline measures, inclusive of demographics, medical history, and the 7-item Hospital Anxiety and Depression Scale anxiety subscale (HADS-A), a validated questionnaire for patients with physical ailments. Scores of 8 or higher indicate clinically significant anxiety levels. A subset of 46 participants provided hair samples for HCC analysis. T-tests and linear regression were used to test associations between HCC and anxiety. The sample was 28.3% female, the mean age was 67.7±12.6 years, and 39.1% of participants reported elevated anxiety levels. HCC was lower in participants with high vs. low anxiety (17.5 vs. 33.4, t=1.98, p=0.055). After adjusting for age and diabetes (both associated with HCC) in a regression model, elevated anxiety remained associated with lower HCC (B=20.7, SE= .2, p=0.049). In essence, contrary to our hypothesis, anxiety and HCC are negatively correlated. Chronic anxiety may overwork the adrenal gland to act as a negative feedback loop to lower cortisol concentrations. Further analyses with larger samples and longitudinal measures are needed to examine the threshold of anxiety in which cortisol concentrations dip, and to test the bidirectional associations between anxiety, HCC and MI events. \n

Project Supervisor Tanya Spruill

Research Areas Health



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Measuring Hair Cortisol Concentrations (HCC) in Myocardial Infarction (MI) Patients and Testing its Association with Anxiety

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[1] Brown University, [2] Institute for Excellence in Health Equity, NYU Langone Health, [3] Department of Population Health, NYU Grossman School of Medicine

NYU Langone Health

AHA SFRN Funded Research

Background

- Myocardial Infarction (MI), or heart attack, is a form of cardiovascular disease (CVD) that is the leading cause of mortality worldwide.
- Elevated psychological anxiety increases the incidence of CVD by 48%, yet mechanisms of this association are not exhaustively understood.
- Cortisol is a glucocorticoid hormone produced by the adrenal glands of the hypothalamic-pituitary-adrenocortical axis to regulate the body's sympathetic response to anxiety.
- Hair cortisol concentration (HCC) is an objective biomarker that may be more applicable for studying the health ramifications of anxiety than traditional saliva, blood and urine samples, as it quantifies cortisol concentrations over time, rather than at a singular point.

Methods

Procedures
- Participants were enrolled in the NYU Women's Heart Attack Research Study (HARP), an ongoing multicenter cohort study, around the time of hospitalization for acute MI.

Eligibility criteria
- Age ≥21
- Patient of NYU Langone
- Within 3 months of acute MI, diagnosed according to Third Universal Definition of MI
- Absence of significant cognitive impairment or psychosis

Measures
- Medical records were reviewed and participants completed self-report measures (demographics, medical history, psychosocial factors)
- Anxiety was assessed with the validated 7-item Hospital Anxiety and Depression Scale anxiety subscale (HADS-A), developed for patients with physical ailments
- Participants cut hair samples from the crown area of the scalp and returned them by mail
- Samples were cut to isolate the 3 cm closest to the scalp and analyzed for hair cortisol concentration (HCC), reflecting cortisol deposition over a ~3-month period before collection

Figure 1. Role of cortisol in the association between stress/anxiety and CVD

Data analysis
- Elevated anxiety was classified as HADS-A ≥ 8
- T-tests, Pearson correlations and multivariable logistic regression analyses were performed to identify predictors of HCC

Results

Table 1. Sample characteristics (N=46)

Variables	Mean ± SD or %
Age	67.7 ± 12.6 years
Sex	28.3% female
	71.7% male
Race/ethnicity	71.7% non-Hispanic White
	13.0% Asian
	8.7% Hispanic (all races)
	4.3% non-Hispanic Black
	2.2% Other
Time since MI	45.9 ± 24.6 days
Body mass index	27.5 ± 4.4 kg/m²
Diabetes	28.3% Yes
	69.6% No
HCC	27.2 ± 30.7 pg/mg
HADS-Anxiety	6.3 ± 4.7
Elevated anxiety (HADS-A ≥ 8)	39.1% Yes
	60.9% No
Current anxiety disorder treatment	15.2% Yes
	84.8% No

Note: MI=myocardial infarction; HCC=hair cortisol concentration; HADS=Hospital Anxiety & Depression Scale

Figures 2-5. Univariate associations (categorical) with HCC level

Fig 2. Mean HCC by Anxiety Level

Fig 3. Mean HCC by Sex

Fig 4. Mean HCC by Diabetes Status

Fig 5. Mean HCC by Current Anxiety Treatment

Table 2. Univariate associations (continuous) with HCC level

Variables	Pearson r	P-value
HADS-Anxiety	-0.189	0.209
Age	0.334	0.027
Body mass index	-0.062	0.682
Time since MI	-0.222	0.180

Table 3. Multivariate associations with HCC level

Variables	B	SE	P-value
Elevated anxiety (HADS-A ≥ 8)	-17.80	8.98	0.055
Age	0.60	0.39	0.135
Diabetes	18.17	10.85	0.102
Current anxiety treatment	-9.31	13.27	0.487

Table 4. Mean HCC by Anxiety Level

Hx anxiety	N	Mean	Std. Dev.
Low anxiety (HADS-A < 8)	35	29.8641	32.2808
High anxiety (HADS-A ≥ 8)	9	11.2062	8.3209

Conclusions & Future Steps

- Contrary to our hypothesis, anxiety and HCC are negatively correlated, as elevated anxiety consistently remained associated with lower HCC.
- Chronic anxiety may overwork the adrenal gland to serve as a negative feedback loop to lower cortisol concentrations.
- Further analyses with larger samples and longitudinal measures are necessary to assess the threshold of anxiety at which cortisol concentrations dip, and to test the bidirectional associations between anxiety, HCC and MI events.
- After understanding this correlation, we hope to lessen these calamitous outcomes by enrolling participants in a Mindfulness Based Cognitive Therapy (MBCT) to target cognitive vulnerabilities by teaching participants to cope with feelings of uncertainty and anxiousness post-MI event.

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Acknowledgments

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Eye-Hand Coordination Data Analysis for Patients with Chronic Cerebral Injury

Eye-hand coordination is critical for performing visually guided movements, and disruptions in this coordination are often observed in individuals with chronic cerebral injury, impacting their motor control and overall functionality. This study focuses on the analysis of eye-hand coordination data using MATLAB, emphasizing data processing and analytical techniques. Data was previously collected using the KineReach and EyeLink systems, capturing detailed movement trajectories and eye-tracking information during various reaching tasks. The primary objective is to utilize MATLAB to segment the dataset into 5-second snippets centered around trigger signals, starting 0.5 seconds before and ending 4.5 seconds after the trigger. Additionally, MATLAB algorithms were developed to detect saccades and analyze the temporal relationships and synchronization between eye and hand movements. Further synchronization analysis will involve temporal alignment techniques to assess the degree of coordination and identify patterns of movement. By identifying patterns and deviations in coordination, this analysis aims to contribute to the development of targeted therapeutic interventions and enhance our understanding of motor control mechanisms in patients with chronic cerebral injuries.

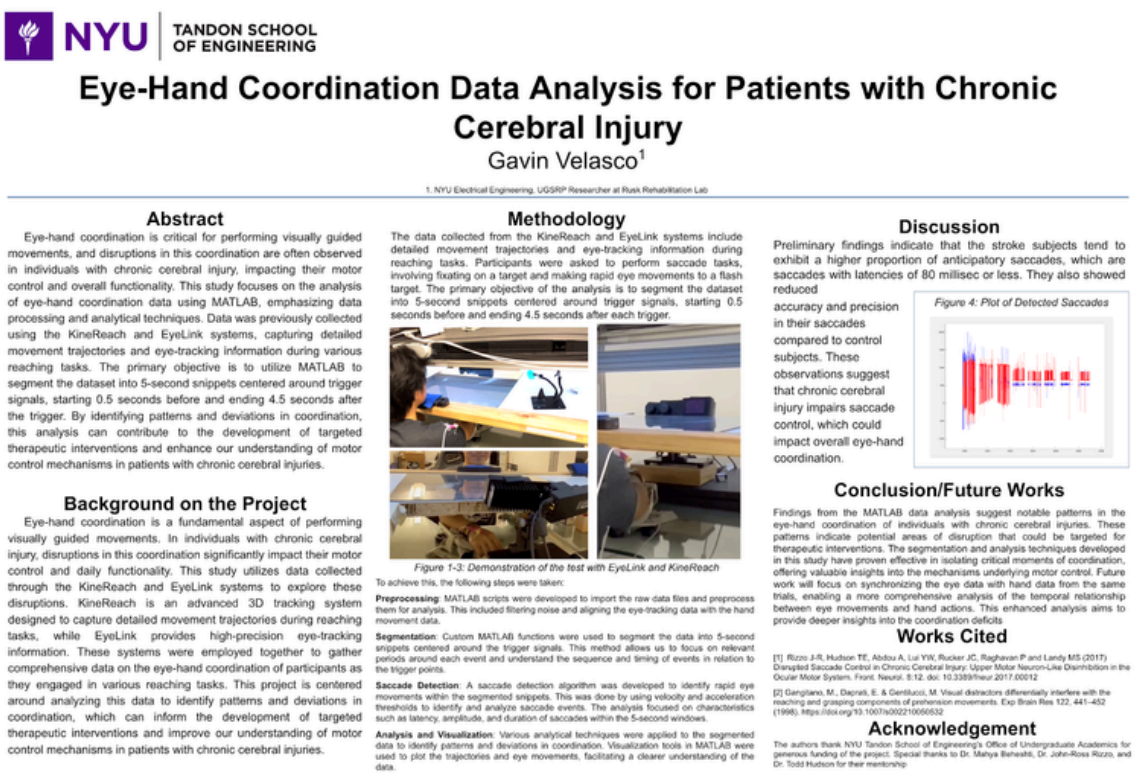
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NYU TANDON SCHOOL OF ENGINEERING

Eye-Hand Coordination Data Analysis for Patients with Chronic Cerebral Injury

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Abstract

Eye-hand coordination is critical for performing visually guided movements, and disruptions in this coordination are often observed in individuals with chronic cerebral injury, impacting their motor control and overall functionality. This study focuses on the analysis of eye-hand coordination data using MATLAB, emphasizing data processing and analytical techniques. Data was previously collected using the KineReach and EyeLink systems, capturing detailed movement trajectories and eye-tracking information during various reaching tasks. The primary objective is to utilize MATLAB to segment the dataset into 5-second snippets centered around trigger signals, starting 0.5 seconds before and ending 4.5 seconds after the trigger. By identifying patterns and deviations in coordination, this analysis can contribute to the development of targeted therapeutic interventions and enhance our understanding of motor control mechanisms in patients with chronic cerebral injuries.

Background on the Project

Eye-hand coordination is a fundamental aspect of performing visually guided movements. In individuals with chronic cerebral injury, disruptions in this coordination significantly impact their motor control and daily functionality. This study utilizes data collected through the KineReach and EyeLink systems to explore these disruptions. KineReach is an advanced 3D tracking system designed to capture detailed movement trajectories during reaching tasks, while EyeLink provides high-precision eye-tracking information. These systems were employed together to gather comprehensive data on the eye-hand coordination of participants as they engaged in various reaching tasks. This project is centered around analyzing this data to identify patterns and deviations in coordination, which can inform the development of targeted therapeutic interventions and improve our understanding of motor control mechanisms in patients with chronic cerebral injuries.

Methodology

The data collected from the KineReach and EyeLink systems include detailed movement trajectories and eye-tracking information during reaching tasks. Participants were asked to perform saccade tasks, involving fixating on a target and making rapid eye movements to a flash target. The primary objective of the analysis is to segment the dataset into 5-second snippets centered around trigger signals, starting 0.5 seconds before and ending 4.5 seconds after each trigger.

Figure 1-3: Demonstration of the test with EyeLink and KineReach

To achieve this, the following steps were taken:

Preprocessing: MATLAB scripts were developed to import the raw data files and preprocess them for analysis. This included filtering noise and aligning the eye-tracking data with the hand movement data.

Segmentation: Custom MATLAB functions were used to segment the data into 5-second snippets centered around the trigger signals. This method allows us to focus on relevant periods around each event and understand the sequence and timing of events in relation to the trigger points.

Saccade Detection: A saccade detection algorithm was developed to identify rapid eye movements within the segmented snippets. This was done by using velocity and acceleration thresholds to identify and analyze saccade events. The analysis focused on characteristics such as latency, amplitude, and duration of saccades within the 5-second windows.

Analysis and Visualization: Various analytical techniques were applied to the segmented data to identify patterns and deviations in coordination. Visualization tools in MATLAB were used to plot the trajectories and eye movements, facilitating a clearer understanding of the data.

Discussion

Preliminary findings indicate that the stroke subjects tend to exhibit a higher proportion of anticipatory saccades, which are saccades with latencies of 80 millisec or less. They also showed reduced accuracy and precision in their saccades compared to control subjects. These observations suggest that chronic cerebral injury impairs saccade control, which could impact overall eye-hand coordination.

Figure 4: Plot of Detected Saccades

Conclusion/Future Works

Findings from the MATLAB data analysis suggest notable patterns in the eye-hand coordination of individuals with chronic cerebral injuries. These patterns indicate potential areas of disruption that could be targeted for therapeutic interventions. The segmentation and analysis techniques developed in this study have proven effective in isolating critical moments of coordination, offering valuable insights into the mechanisms underlying motor control. Future work will focus on synchronizing the eye data with hand data from the same trials, enabling a more comprehensive analysis of the temporal relationship between eye movements and hand actions. This enhanced analysis aims to provide deeper insights into the coordination deficits

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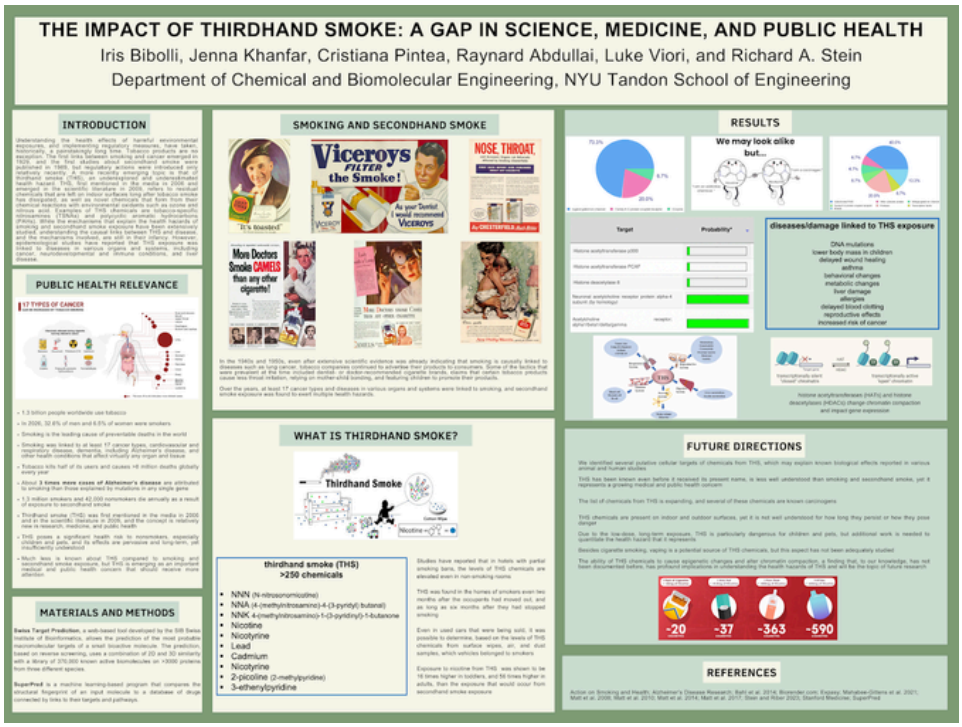
Health

The Impact of Thirdhand Smoke: A Gap in Science, Medicine and Public Health

Understanding the health effects of harmful environmental exposures, and implementing regulatory measures, require a painstakingly long time, and tobacco products are no exception. The first links between smoking and cancer emerged in 1929, and the first studies about secondhand smoke were published in 1989, but regulatory actions were introduced only relatively recently. A much less-known health impact of smoking is the topic of third-hand smoke (THS), an underexplored and underestimated health hazard. THS, first mentioned in the media in 2006 and in scientific literature in 2009, refers to residual chemicals that are left on indoor surfaces long after tobacco smoke has dissipated, as well as novel chemicals that form from their chemical reactions with environmental oxidants such as ozone and nitrous acid, such as tobacco-specific nitrosamines (TSNAs) and polycyclic aromatic hydrocarbons (PAHs). To better understand the cellular and molecular targets of key THS chemicals, we used Swiss Prediction and Super-PRED, two predictive tools that are powered to identify cellular and molecular targets of chemical entities. Results. We found that several components of THS act on genes and pathways that have not been reported so far in the literature and explain many epidemiological findings. Notably, we are able to explain how nicotyrine, an oxidation product of nicotine, an addictive chemical, is a carcinogen. Despite the minimal differences in the chemical structures of the two, their cellular targets are markedly distinct. We also found, to our knowledge for the first time, that THS components can modulate the epigenetic machinery in host cells. Our findings indicate that THS chemicals affect signaling in several tissues, including the central nervous system and the liver, and change chromatin compaction, providing an explanation for epidemiological studies and suggesting broad effects with a far-reaching health impact. These perturbations explain the link between THS and various conditions, including developmental delay, immune conditions, and cancer.

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Genetically Engineering Stem Cells into Neurons and Immune Cells

Stem cells have the capability to transform into specialized cells with unique functions, otherwise known as differentiated cells. This slow and labor intensive process can be accelerated by integrating synthetic genetic material, known as a gene circuit, into stem cells, reprogramming them into a desired cell type. In this study, gene circuits are used to express proteins called transcription factors (TFs) which differentiate stem cells into macrophages and neurons. Our first objective was to use a gene circuit that controls TF expression in the presence of an antibiotic to convert induced pluripotent stem cells (iPSCs) into induced macrophages (iMACs), a type of immune cell. The second goal was to make the iMACs express a brain-derived neurotrophic factor (BDNF), a protein that supports neuronal development. When the BDNF gene circuit is integrated into iPSCs, the iMACs produce this protein, allowing surrounding neuronal cells to utilize it. Once the BDNF-expressing macrophages are co-cultured with neurons, the neurons are expected to grow and regenerate, mimicking a healthy brain cell environment. Using this system, the iMACs automatically produce BDNF to aid the regeneration of healthy neurons. iMAC gene expression was analyzed to confirm it had genes that code for TFs required for macrophage differentiation. Both cell lines successfully converted into macrophages and neurons, functioning as disease targeting mechanisms. To efficiently reprogram iPSCs into macrophages and neurons, the right TFs must be identified to express in the cells. Because of the large variety of TFs, our third goal is to develop a machine learning algorithm to select only the crucial proteins required for our genetic circuits. Our efforts in computational and synthetic biology improve the efficiency and accuracy of the cell differentiation processes by making cells reprogrammable for regenerative medicine and targeted therapies for conditions like cancer and Alzheimer's disease.

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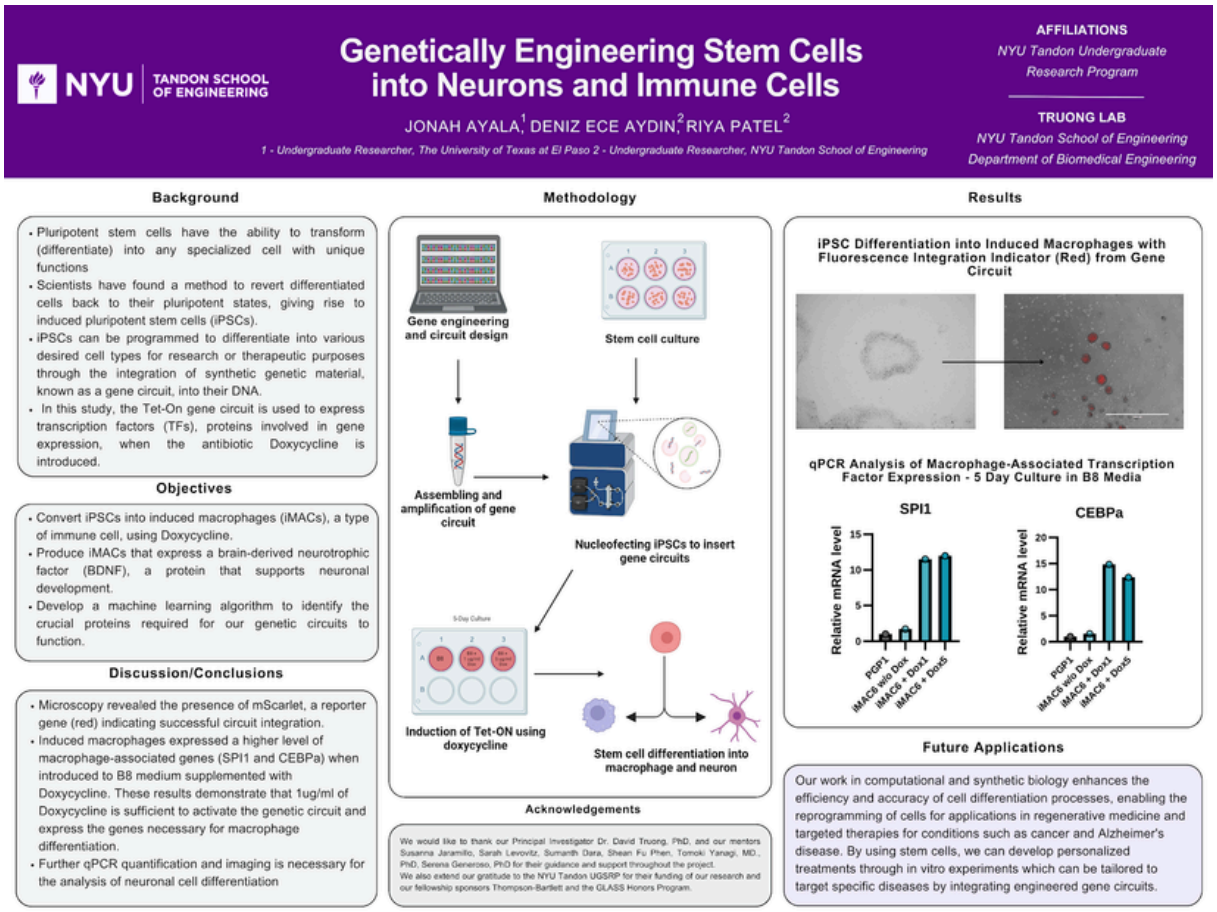
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Deciphering Mechanotransduction in CAR T-cells for Ennhanced Immunotherapeutic Efficacy

Chimeric antigen receptor (CAR) T cell therapy is revolutionizing cancer treatment. Mechanical forces exerted by CAR T cells on cancer cells are crucial for their cytotoxicity, involving complex mechanotransductive signaling and cytoskeletal dynamics. However, the underlying mechanosensing and signaling pathways remain poorly understood. Our study investigates the biomechanical machinery driving CAR T cell activation and cytotoxicity, focusing on CAR-mediated mechanosensation, cytoskeleton dynamics, and Piezo1-mediated signaling. Using a force-sensing micromechanical platform with immunofluorescent imaging, we measured synaptic force dynamics and cytoskeletal changes in single CAR T cells interacting with cancer cells. Results show that CAR T cell activation correlates with increased synaptic force and surface activation markers. Conversely, patient-derived CAR T cells exhibit reduced mechanosensing capabilities, weaker cytoskeletal machinery, and aberrant Piezo1 channel activity. This research demonstrates that manipulating these mechano-biomarkers and signaling pathways can enhance CAR T cell therapy efficacy. Our findings provide valuable insights for optimizing CAR T cell function, potentially improving outcomes for cancer patients.

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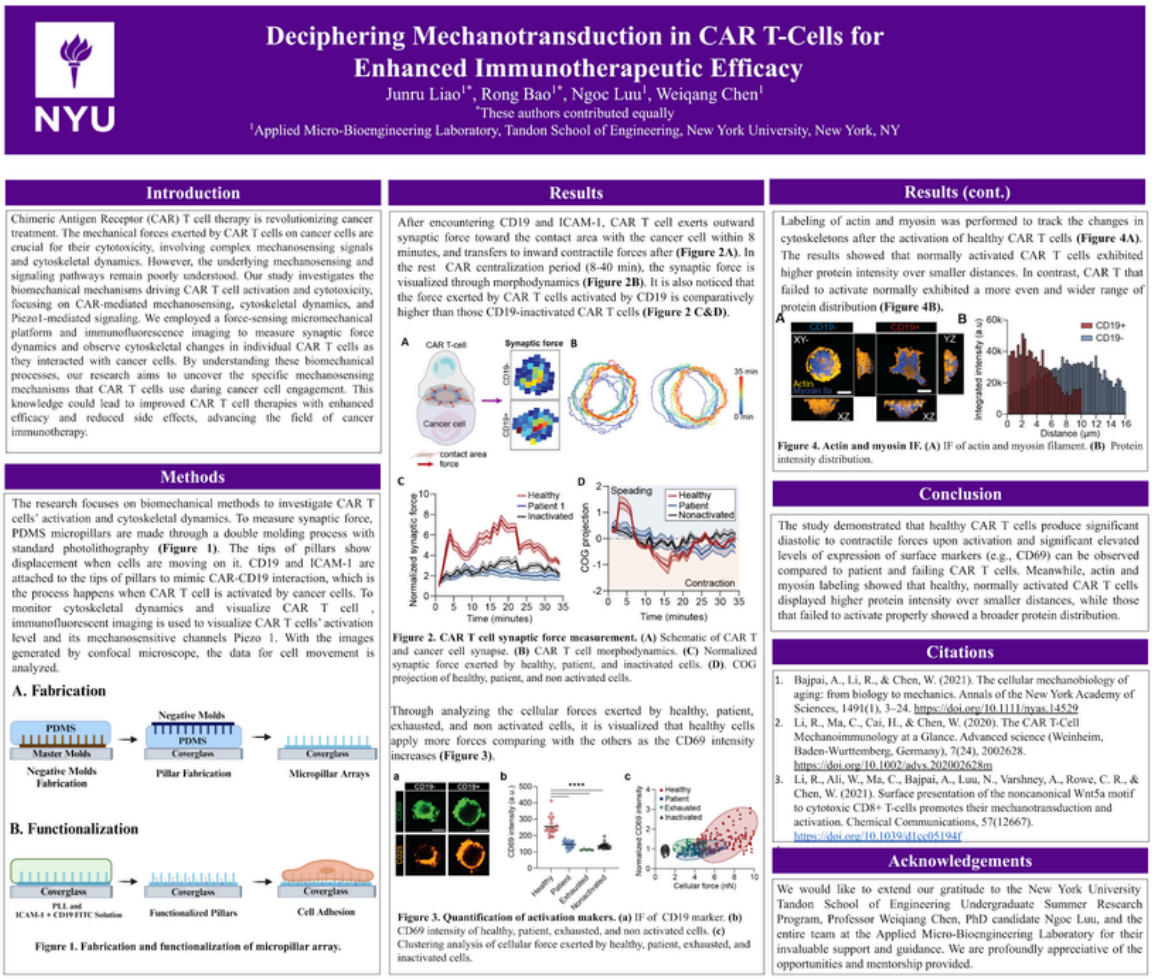
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Deciphering Mechanotransduction in CAR T-Cells for Enhanced Immunotherapeutic Efficacy

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Introduction

Chimeric Antigen Receptor (CAR) T cell therapy is revolutionizing cancer treatment. The mechanical forces exerted by CAR T cells on cancer cells are crucial for their cytotoxicity, involving complex mechanosensing signals and cytoskeletal dynamics. However, the underlying mechanosensing and signaling pathways remain poorly understood. Our study investigates the biomechanical mechanisms driving CAR T cell activation and cytotoxicity, focusing on CAR-mediated mechanosensing, cytoskeletal dynamics, and Piezo1-mediated signaling. We employed a force-sensing micromechanical platform and immunofluorescence imaging to measure synaptic force dynamics and observe cytoskeletal changes in individual CAR T cells as they interacted with cancer cells. By understanding these biomechanical processes, our research aims to uncover the specific mechanosensing mechanisms that CAR T cells use during cancer cell engagement. This knowledge could lead to improved CAR T cell therapies with enhanced efficacy and reduced side effects, advancing the field of cancer immunotherapy.

Methods

The research focuses on biomechanical methods to investigate CAR T cells' activation and cytoskeletal dynamics. To measure synaptic force, PDMS micropillars are made through a double molding process with standard photolithography **(Figure 1)**. The tips of pillars show displacement when cells are moving on it. CD19 and ICAM-1 are attached to the tips of pillars to mimic CAR-CD19 interaction, which is the process happens when CAR T cell is activated by cancer cells. To monitor cytoskeletal dynamics and visualize CAR T cell , immunofluorescent imaging is used to visualize CAR T cells' activation level and its mechanosensitive channels Piezo 1. With the images generated by confocal microscope, the data for cell movement is analyzed.

A. Fabrication

B. Functionalization

Figure 1. Fabrication and functionalization of micropillar array.

Results

After encountering CD19 and ICAM-1, CAR T cell exerts outward synaptic force toward the contact area with the cancer cell within 8 minutes, and transfers to inward contractile forces after **(Figure 2A)**. In the rest CAR centralization period (8-40 min), the synaptic force is visualized through morphodynamics **(Figure 2B)**. It is also noticed that the force exerted by CAR T cells activated by CD19 is comparatively higher than those CD19-inactivated CAR T cells **(Figure 2 C&D)**.

Figure 2. CAR T cell synaptic force measurement. **(A)** Schematic of CAR T and cancer cell synapse. **(B)** CAR T cell morphodynamics. **(C)** Normalized synaptic force exerted by healthy, patient, and inactivated cells. **(D)** COG projection of healthy, patient, and non activated cells.

Through analyzing the cellular forces exerted by healthy, patient, exhausted, and non activated cells, it is visualized that healthy cells apply more forces comparing with the others as the CD69 intensity increases **(Figure 3)**.

Figure 3. Quantification of activation makers. **(a)** IF of CD19 marker. **(b)** CD69 intensity of healthy, patient, exhausted, and non activated cells. **(c)** Clustering analysis of cellular force exerted by healthy, patient, exhausted, and inactivated cells.

Results (cont.)

Labeling of actin and myosin was performed to track the changes in cytoskeletons after the activation of healthy CAR T cells **(Figure 4A)**. The results showed that normally activated CAR T cells exhibited higher protein intensity over smaller distances. In contrast, CAR T that failed to activate normally exhibited a more even and wider range of protein distribution **(Figure 4B)**.

Figure 4. Actin and myosin IF. **(A)** IF of actin and myosin filament. **(B)** Protein intensity distribution.

Conclusion

The study demonstrated that healthy CAR T cells produce significant diastolic to contractile forces upon activation and significant elevated levels of expression of surface markers (e.g., CD69) can be observed compared to patient and failing CAR T cells. Meanwhile, actin and myosin labeling showed that healthy, normally activated CAR T cells displayed higher protein intensity over smaller distances, while those that failed to activate properly showed a broader protein distribution.

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Automated Pre-Processing of Medical Audio Data for ECoG-to-Text Neural Decoding

The research develops an automated pipeline for pre-processing medical audio data, which is crucial for advancing neural decoding research. Traditional methods involving human transcription are time-consuming and often inaccurate, particularly for lengthy or noisy audio files. The project addresses these challenges by automating denoising, voice activity detection, and speaker diarization, facilitating the pre-processing phase for training a novel speech neural decoding model. The team developed a comprehensive system incorporating high-quality transcription and diarization inspired by WhisperX, a custom audio denoising module, and applied the Resemblyzer algorithm for creating speaker embeddings. These embeddings train a model that accurately identifies and extracts the target speaker's speech from multi-speaker audio files, particularly focusing on patient speech. To evaluate the pipeline's effectiveness, a bottom-up dynamic programming algorithm was developed to align transcriptions and compare the accuracy of the automated process with manual labeling. Preliminary results show that the pipeline significantly reduces noise and effectively identifies patient speech, enhancing the quality of audio analysis critical for accurate neural decoding. The automated approach has the potential to improve neural speech decoding and mental health diagnostics, paving the way for more personalized and effective healthcare solutions by offering more accurate predictions of patient speech and a better understanding of brain activity.

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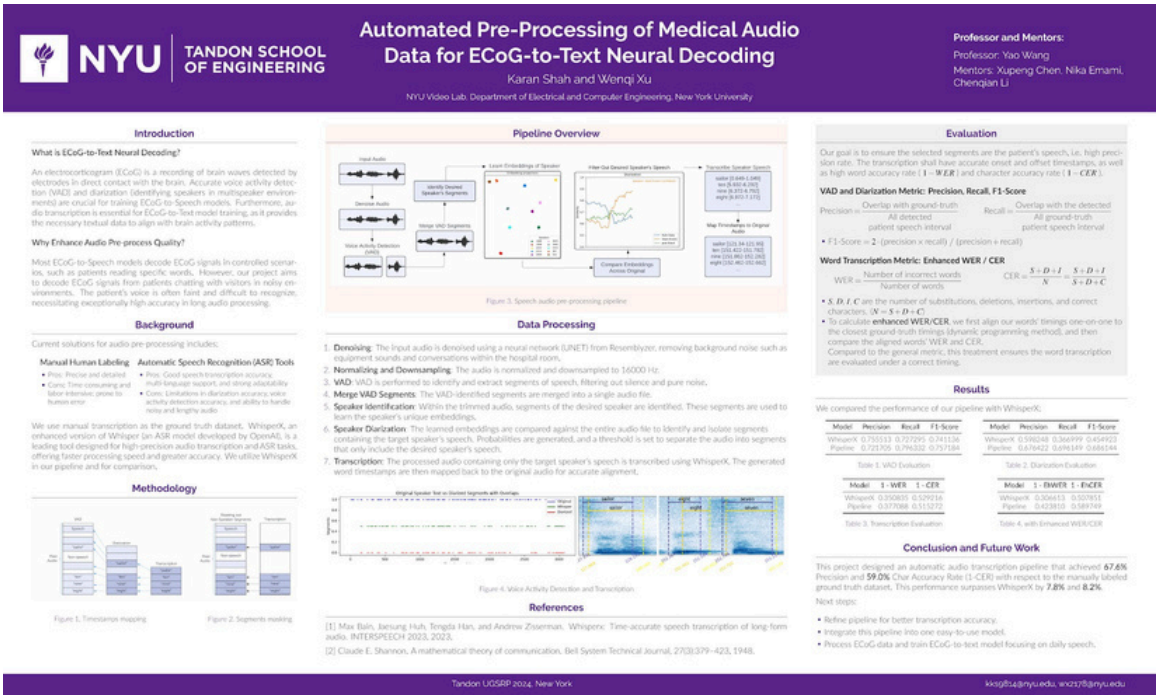
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PDAC Organoids-on-a-chip to Model the Tumor Microenvironmental and Test Immunotherapies

Pancreatic Ductal Adenocarcinoma (PDAC) has one of the lowest 5-year survival rates of any cancer at 12.5%. The complex tumor microenvironment (TME) is a major barrier to developing effective treatments. The key characteristics of the TME are desmoplasia and cell signaling between immune cells and cancer cells that disrupt the proper cell mechanisms and inhibit the efficacy of novel cancer treatments like immunotherapy. Firstly, to better understand the PDAC TME and dissect the mechanism of immunosuppression, we bioengineered a PDAC organoids-on-a-chip model that replicates the in vivo PDAC TME by combining patient-derived PDAC organoids and microfluidic-based organ-on-a-chip technology. The patient-derived organoids mimic the main characteristics of the in vivo counterparts while the organ-on-a-chip enhances the in vitro environment with stromal and immune niche cells and reproducibility. The PDMS-based microfluidic chip was produced using soft lithography and loaded with patient-derived PDAC organoids, patient-derived cancer-associated fibroblasts, tumor-associated macrophages, regulatory T cells, and blood vessels. The model reproduced hypovascularity in the PDAC stromal niche as seen through a lower expression of CD31 when compared to the non-PDAC stromal niche. Desmoplasia was observed with a higher expression level of α-smooth muscle actin on cancer-associated macrophages and a more extensive deposition of ECM components. The presence of pro-tumor, inflammation-related, and immunosuppressive cytokines increased in the PDAC niche showcasing the immunosuppression within the TME. Next, we tested chimeric antigen receptors (CAR) T-cell immunotherapy on the chip. Anti-mesothelin (MSLN) CAR T-cells were infused on the chip and migrated through the vessels into the tumor niche. We achieved in situ monitoring of the infiltration of CAR T-cells on chip and characterized the cytotoxicity of CAR T-cells with the secretion of granzyme B. In conclusion, our PDAC organoids-on-a-chip model replicates the complex tumor microenvironment and can be used to test novel immunotherapies like CAR T-cell therapy. More promisingly the model serves as a platform for the development of new and personalized treatments.

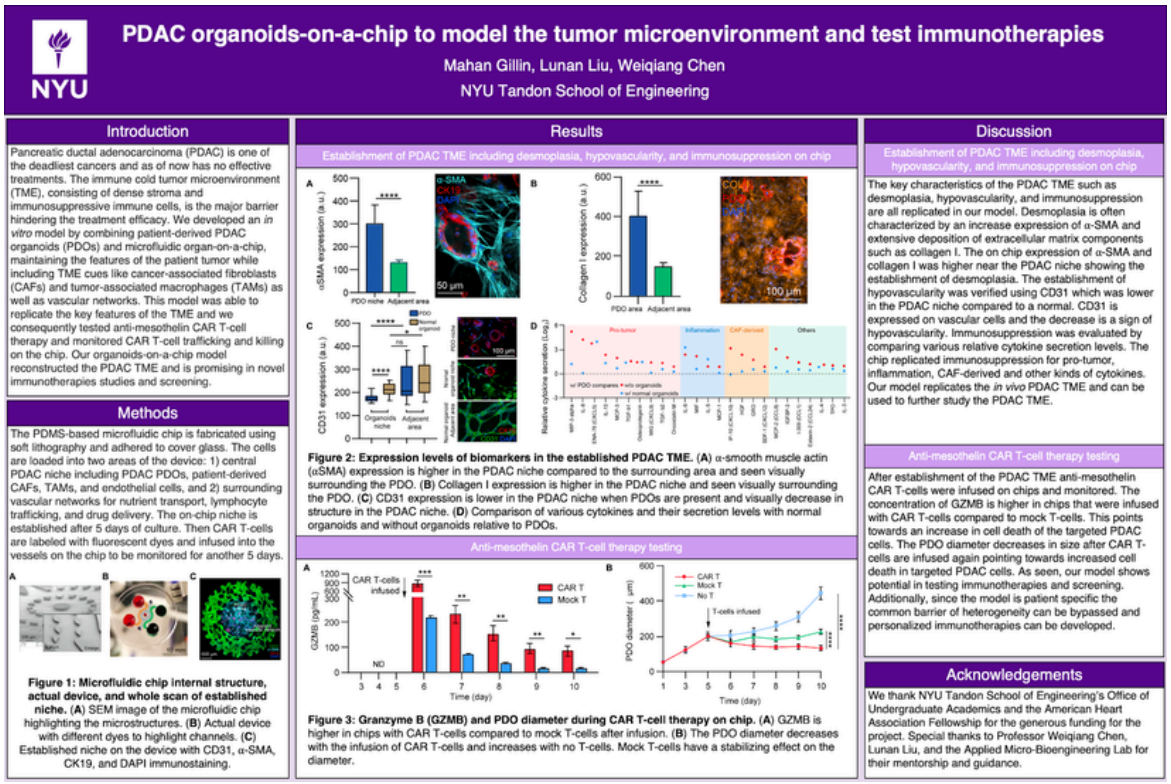
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PDAC organoids-on-a-chip to model the tumor microenvironment and test immunotherapies

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NYU Tandon School of Engineering

Introduction

Pancreatic ductal adenocarcinoma (PDAC) is one of the deadliest cancers and as of now has no effective treatments. The immune cold tumor microenvironment (TME), consisting of dense stroma and immunosuppressive immune cells, is the major barrier hindering the treatment efficacy. We developed an *in vitro* model by combining patient-derived PDAC organoids (PDOs) and microfluidic organ-on-a-chip, maintaining the features of the patient tumor while including TME cues like cancer-associated fibroblasts (CAFs) and tumor-associated macrophages (TAMs) as well as vascular networks. This model was able to replicate the key features of the TME and we consequently tested anti-mesothelin CAR T-cell therapy and monitored CAR T-cell trafficking and killing on the chip. Our organoids-on-a-chip model reconstructed the PDAC TME and is promising in novel immunotherapies studies and screening.

Methods

The PDMS-based microfluidic chip is fabricated using soft lithography and adhered to cover glass. The cells are loaded into two areas of the device: 1) central PDAC niche including PDAC PDOs, patient-derived CAFs, TAMs, and endothelial cells, and 2) surrounding vascular networks for nutrient transport, lymphocyte trafficking, and drug delivery. The on-chip niche is established after 5 days of culture. Then CAR T-cells are labeled with fluorescent dyes and infused into the vessels on the chip to be monitored for another 5 days.

Figure 1: Microfluidic chip internal structure, actual device, and whole scan of established niche. (A) SEM image of the microfluidic chip highlighting the microstructures. (B) Actual device with different dyes to highlight channels. (C) Established niche on the device with CD31, α-SMA, CK19, and DAPI immunostaining.

Results

Establishment of PDAC TME including desmoplasia, hypovascularity, and immunosuppression on chip

Figure 2: Expression levels of biomarkers in the established PDAC TME. (A) α-smooth muscle actin (αSMA) expression is higher in the PDAC niche compared to the surrounding area and seen visually surrounding the PDO. (B) Collagen I expression is higher in the PDAC niche and seen visually surrounding the PDO. (C) CD31 expression is lower in the PDAC niche when PDOs are present and visually decrease in structure in the PDAC niche. (D) Comparison of various cytokines and their secretion levels with normal organoids and without organoids relative to PDOs.

Anti-mesothelin CAR T-cell therapy testing

Figure 3: Granzyme B (GZMB) and PDO diameter during CAR T-cell therapy on chip. (A) GZMB is higher in chips with CAR T-cells compared to mock T-cells after infusion. (B) The PDO diameter decreases with the infusion of CAR T-cells and increases with no T-cells. Mock T-cells have a stabilizing effect on the diameter.

Discussion

Establishment of PDAC TME including desmoplasia, hypovascularity, and immunosuppression on chip

The key characteristics of the PDAC TME such as desmoplasia, hypovascularity, and immunosuppression are all replicated in our model. Desmoplasia is often characterized by an increase expression of α-SMA and extensive deposition of extracellular matrix components such as collagen I. The on chip expression of α-SMA and collagen I was higher near the PDAC niche showing the establishment of desmoplasia. The establishment of hypovascularity was verified using CD31 which was lower in the PDAC niche compared to a normal. CD31 is expressed on vascular cells and the decrease is a sign of hypovascularity. Immunosuppression was evaluated by comparing various relative cytokine secretion levels. The chip replicated immunosuppression for pro-tumor, inflammation, CAF-derived and other kinds of cytokines. Our model replicates the *in vivo* PDAC TME and can be used to further study the PDAC TME.

Anti-mesothelin CAR T-cell therapy testing

After establishment of the PDAC TME anti-mesothelin CAR T-cells were infused on chips and monitored. The concentration of GZMB is higher in chips that were infused with CAR T-cells compared to mock T-cells. This points towards an increase in cell death of the targeted PDAC cells. The PDO diameter decreases in size after CAR T-cells are infused again pointing towards increased cell death in targeted PDAC cells. As seen, our model shows potential in testing immunotherapies and screening. Additionally, since the model is patient specific the common barrier of heterogeneity can be bypassed and personalized immunotherapies can be developed.

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The Impact of High-Fat Diets on Behavior in Zebrafish

Obesity is a global epidemic driven by the accessibility of high-fat food, and has quickly become one of the most concerning public health challenges. Previous studies have demonstrated the cognitive dysfunction of obesity, such as aggressiveness and anxiety. In this study zebrafish (danio rerio) are fed an obesogenic diet to induce rapid fat gain. Novel tank-diving tests and exposure tests using a robotic predator fish as a stressor can be used to induce anxiety. The locomotion of the fish during these anxiety assays can be recorded with high-speed cameras to be processed to determine their location and velocity over the testing time. It is expected that the longer a fish spends in the lower part of the chamber the higher its anxiety levels. A respirometer chamber can be used to observe the oxygen consumption of fish at critical speeds, with a higher oxygen consumption expected among the obesogenic fish. While not the purpose of the study, a sex-specific difference is expected in this experiment. Comparing these measurements between fish on a high-fat obesogenic diet and a control diet can prove the link between anxiety and obesity.

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The Impact of High-Fat Diets on Behavior in Zebrafish

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Abstract

We present a methodology to investigate whether an obesogenic diet will lead to behavioral and physiological effects of zebrafish. Specifically, we study the way that such a diet will affect the locomotion and cognition in zebrafish by increasing anxiety-like behaviors.

Problem Statement

Obesity is a global epidemic driven by the accessibility of high-fat food, and has quickly become one of the most concerning public health challenges. Previous studies have demonstrated the cognitive dysfunction of obesity, such as aggressiveness and anxiety [1]. In this study zebrafish (*Danio rerio*) are overfed with a regular diet of high-fat brine shrimp feed Artemia to induce rapid fat gain, with an expected higher weight variance. A sex-specific difference is expected in this experiment, with previous studies finding female fish to have gained more weight and express less anxiety when given the same diet[1].

Zebrafish have been established as an animal model in a wide range of research fields (Image Credit: isoft)

Anxiety Behavioral Assay

A novel tank-diving test is used to observe the movement and behaviors of fish when placed in an unfamiliar tank using high-speed cameras. The tank is divided into upper and lower levels, and the number of entries into the upper or lower halves of the tank, the distance travelled, velocity over time, and time spent in each section of the tank are recorded. Since fish express higher anxiety-like behaviors the longer they stay in the lower part of the chamber, we expect they they spend more time there with less entries into the upper chamber.

Novel tank-diving tests separate the tank into upper and lower levels.

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Predatory Behavioral Assay

Behavioral assays that assess response to stress may also be accomplished using a robotic predator as a stimulus. Previous studies indicate that zebrafish exhibit associative learning for similar stimuli in the form of an opposing school of fish [2]. Therefore we expect that the fish will stay in the bottom of the tank away from the robotic predator and experience higher anxiety levels.

A robotic fish resembling a predator may be used to induce anxiety in fish, and associative learning.

Contact

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Oxygen Consumption

To investigate the effects of an obesogenic diet on metabolism, we utilize a respirometer system (Loligo Autoresp) that measures the rate of oxygen consumption of fish. Specifically, we place the fish in a swim tunnel and incrementally increase the flow speed, to reach the maximum speed the fish can swim without exhaustion. Throughout this process, we measure the oxygen consumption of the fish. This allows us to identify the energy efficiency between fish on an obesogenic or non-obesogenic diet.

Loligo® AutoResp™ Swim Mini apparatus, where the velocity of the swim channel can be controlled, and the oxygen or air saturation of the water can be measured

Expected Results

When comparing the obesogenic fish to the control, we expect a higher level of oxygen consumption in obesogenic fish due to a decrease in cardiovascular performance. We also expected that the obesogenic diet would result in an increase in anxiety-like behaviors and lower mobility when exposed to stressing stimuli like a robotic predator replica fish.

Utilizing Genomic Alterations in Mouse Tumors to Predict Immune Evasion in Cancer

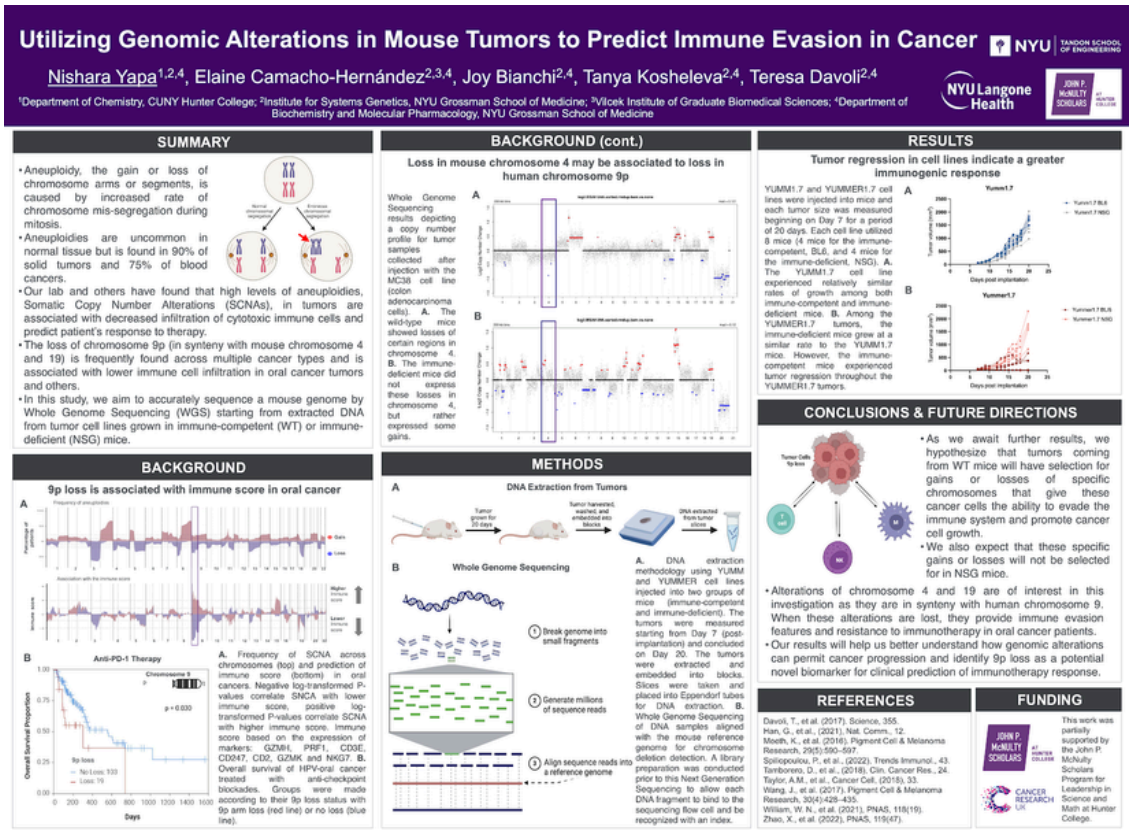
Aneuploidy, the gain or loss of chromosome arms or segments, is found in 90% of solid tumors. Our lab and others have shown that cancer aneuploidies are chromosome specific, with common events across tumor types. Among different cancer types, including oral, bladder, esophageal, and pancreatic, the loss of chromosome 9p arm is frequent (about 30% of patients) associated with poor response to immunotherapy and decreased levels of cytotoxic immune cells (such as CD8+ T cells and NK cells) into the tumor (immune cold). In this study, we aim to accurately sequence a mouse genome by Whole Genome Sequencing (WGS) starting from extracted DNA from tumor cell lines grown in immune-competent (WT) or immune-deficient (NSG) mice. After library preparation with the extracted DNA, Next Generation Sequencing (NGS) will allow us to examine the genome and the alterations in the tumors. Finally, we will analyze the sequenced genome from the collected tumors and compare the different genomic events detected. We hypothesize that tumors coming from WT mice will have selection for gains or losses of specific chromosomes that give these cancer cells the ability to evade the immune system and promote cancer cell growth. We also expect that these specific gains or losses will not be selected for in NSG mice. Alterations of chromosome 4 and 19, in particular, are of interest in this investigation as they are in synteny with human chromosome 9. When these alterations are lost, they provide immune evasion features and resistance to immunotherapy in oral cancer patients. Our results will help us better understand how genomic alterations can permit cancer progression and identify 9p loss as a potential novel biomarker for clinical prediction of immunotherapy response.

Project Supervisor Teresa Davoli

Research Areas Health



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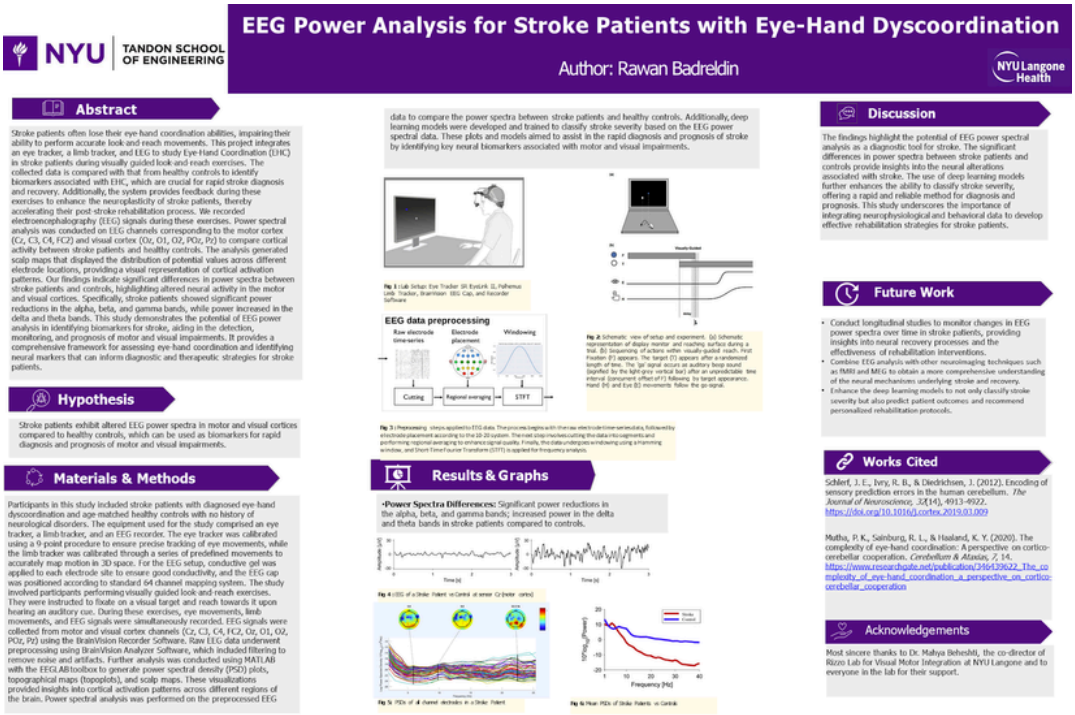
EEG Power Analysis for Stroke Patients with Eye-Hand Dyscoordination

Stroke patients often lose their eye-hand coordination abilities, impairing their ability to perform accurate look-and-reach movements. This project integrates an eye tracker, a limb tracker, and EEG to study Eye-Hand Coordination (EHC) in stroke patients during visually guided look-and-reach exercises. The collected data is compared with that from healthy controls to identify biomarkers associated with EHC, which are crucial for rapid stroke diagnosis and recovery. Additionally, the system provides feedback during these exercises to enhance the neuroplasticity of stroke patients, thereby accelerating their post-stroke rehabilitation process.

Project Supervisor John-Ross Rizzo
Research Areas Health
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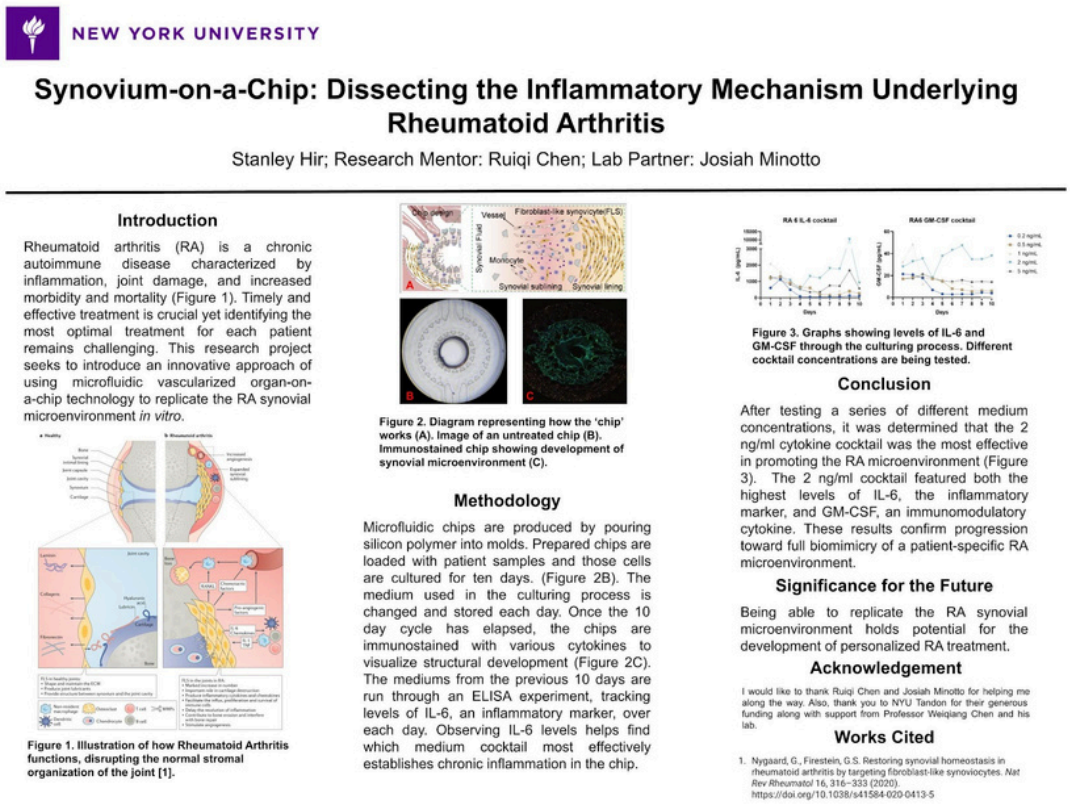
Synovium-on-a-Chip: Dissecting the Inflammatory Mechanism Underlying Rheumatoid Arthritis

Rheumatoid arthritis (RA) is a chronic autoimmune disease characterized by inflammation, joint damage, and increased morbidity and mortality. Timely and effective treatment is crucial for managing this illness, yet identifying the most optimal treatment for each patient remains challenging. Current methods have yet to successfully predict treatment outcomes, highlighting the need for advanced models. This research project seeks to introduce an innovative approach by using microfluidic vascularized organ-on-a-chip technology to replicate the RA synovial microenvironment in vitro. The initial focus of this project is engineering a patient-derived model that accurately mimics the stromal organization and cellular structure observed in specific RA patients. Results obtained through real-time immunostaining and imaging have allowed for the observation of cellular and transcriptomic signatures and the spatial organization of synoviocytes. These results have provided a detailed understanding of RA stromal microenvironment variability among patients. Once RA pathogenesis is established within the Synovium-on-a-Chip, various immunotherapies can be tested on the model. Through analysis of cellular proliferation, cytokine production, and matrix metalloproteinase expression levels, insights can be derived into the efficacy of different treatments. Being able to replicate the microenvironment of RA with the Synovium-on-a-Chip model provides superior biomimicry when compared to existing methods. Overall, this advancement holds significant potential for personalizing RA treatment through patient-derived samples and, hopefully, improving RA patient outcomes one day.

Project Supervisor Weiqiang Chen
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Research Staff Lunan Liu, Huishu Wang



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Synovium-on-a-Chip: Dissecting the Inflammatory Mechanism Underlying Rheumatoid Arthritis

Stanley Hir; Research Mentor: Ruiqi Chen; Lab Partner: Josiah Minotto

Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune disease characterized by inflammation, joint damage, and increased morbidity and mortality (Figure 1). Timely and effective treatment is crucial yet identifying the most optimal treatment for each patient remains challenging. This research project seeks to introduce an innovative approach of using microfluidic vascularized organ-on-a-chip technology to replicate the RA synovial microenvironment *in vitro*.

Figure 1. Illustration of how Rheumatoid Arthritis functions, disrupting the normal stromal organization of the joint [1].

Figure 2. Diagram representing how the 'chip' works (A). Image of an untreated chip (B). Immunostained chip showing development of synovial microenvironment (C).

Methodology

Microfluidic chips are produced by pouring silicon polymer into molds. Prepared chips are loaded with patient samples and those cells are cultured for ten days. (Figure 2B). The medium used in the culturing process is changed and stored each day. Once the 10 day cycle has elapsed, the chips are immunostained with various cytokines to visualize structural development (Figure 2C). The mediums from the previous 10 days are run through an ELISA experiment, tracking levels of IL-6, an inflammatory marker, over each day. Observing IL-6 levels helps find which medium cocktail most effectively establishes chronic inflammation in the chip.

Figure 3. Graphs showing levels of IL-6 and GM-CSF through the culturing process. Different cocktail concentrations are being tested.

Conclusion

After testing a series of different medium concentrations, it was determined that the 2 ng/ml cytokine cocktail was the most effective in promoting the RA microenvironment (Figure 3). The 2 ng/ml cocktail featured both the highest levels of IL-6, the inflammatory marker, and GM-CSF, an immunomodulatory cytokine. These results confirm progression toward full biomimicry of a patient-specific RA microenvironment.

Significance for the Future

Being able to replicate the RA synovial microenvironment holds potential for the development of personalized RA treatment.

Acknowledgement

I would like to thank Ruiqi Chen and Josiah Minotto for helping me along the way. Also, thank you to NYU Tandon for their generous funding along with support from Professor Weiqiang Chen and his lab.

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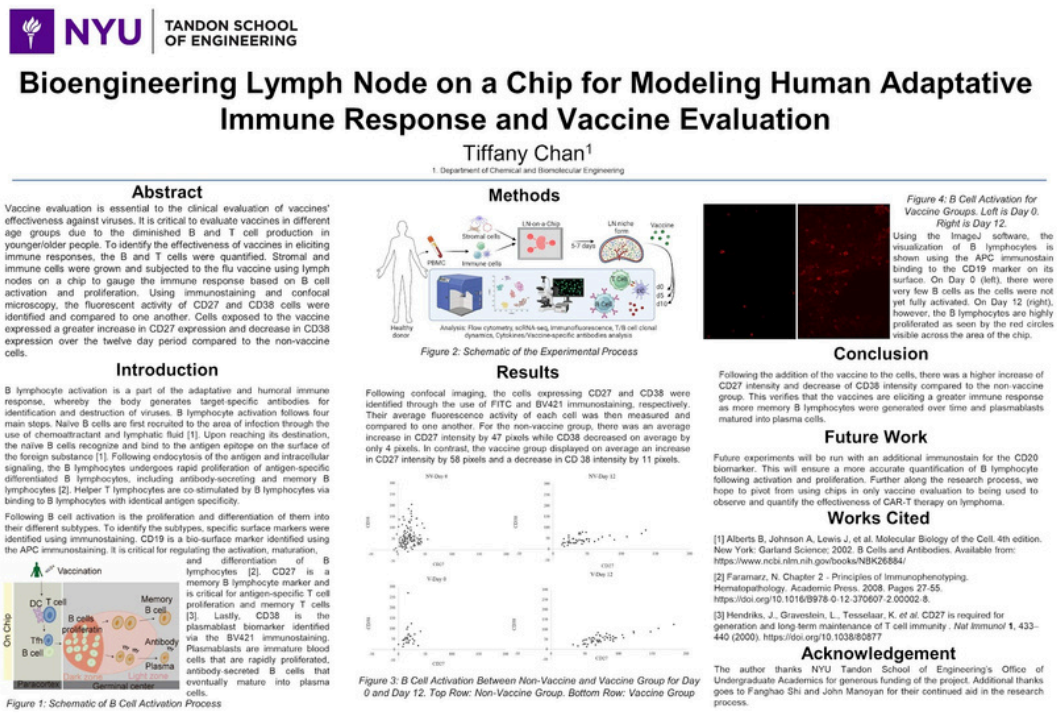
Bioengineering Lymph node-on a Chip for Modeling Human Adaptive Immune Responses and Vaccine Evaluation

Lymph-node-on-a-chip (LN) is a chip system used to model and replicate the basic functions of an organic lymph node. Growing on a chip allows for a higher degree of biomimicry to an organic lymph node due to its 3D structure, allowing for a higher accuracy on the elicited responses and results. The chips are made from polydimethylsiloxane (PDMS), whereby fibroblasts, immune cells, and dendritic cells are grown to replicate the structure of a lymph node. Lymph nodes function to filter out the lymphatic fluids containing damaged cells and store immune cells, B and T lymphocytes, that attack harmful organisms such as bacteria and viruses. This project aims to use the LN to gauge the effectiveness of vaccines in different age groups. It is critical to evaluate vaccines in different age groups specifically due to the diminished B and T cell production in younger/older people. Thus, those groups are more susceptible to various illnesses. By identifying the effectiveness, researchers can better develop vaccines to prevent the rampant spread of diseases, such as COVID-19. In this experiment, stromal and immune cells were grown on the LNs and were either given or not given the flu vaccine to gauge the immune response based on B cell activation and proliferation. Over a twelve-day period, chips were taken every two days to determine the degree of B lymphocyte activation over time. Using immunostaining and confocal microscopy, the lymphocytes were visualized and the fluorescent activity of CD27 and CD38 labeled cells were identified and compared to one another. Cells exposed to the vaccine expressed a greater increase in CD27 expression and a decrease in CD38 expression over the twelve days compared to the non-vaccine cells.

Project Supervisor Weiqiang Chen
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NYU TANDON SCHOOL OF ENGINEERING

Bioengineering Lymph Node on a Chip for Modeling Human Adaptative Immune Response and Vaccine Evaluation

Tiffany Chan[1]

1. Department of Chemical and Biomolecular Engineering

Abstract

Vaccine evaluation is essential to the clinical evaluation of vaccines' effectiveness against viruses. It is critical to evaluate vaccines in different age groups due to the diminished B and T cell production in younger/older people. To identify the effectiveness of vaccines in eliciting immune responses, the B and T cells were quantified. Stromal and immune cells were grown and subjected to the flu vaccine using lymph nodes on a chip to gauge the immune response based on B cell activation and proliferation. Using immunostaining and confocal microscopy, the fluorescent activity of CD27 and CD38 cells were identified and compared to one another. Cells exposed to the vaccine expressed a greater increase in CD27 expression and decrease in CD38 expression over the twelve day period compared to the non-vaccine cells.

Introduction

B lymphocyte activation is a part of the adaptative and humoral immune response, whereby the body generates target-specific antibodies for identification and destruction of viruses. B lymphocyte activation follows four main steps. Naïve B cells are first recruited to the area of infection through the use of chemoattractant and lymphatic fluid [1]. Upon reaching its destination, the naïve B cells recognize and bind to the antigen epitope on the surface of the foreign substance [1]. Following endocytosis of the antigen and intracellular signaling, the B lymphocytes undergoes rapid proliferation of antigen-specific differentiated B lymphocytes, including antibody-secreting and memory B lymphocytes [2]. Helper T lymphocytes are co-stimulated by B lymphocytes via binding to B lymphocytes with identical antigen specificity.

Following B cell activation is the proliferation and differentiation of them into their different subtypes. To identify the subtypes, specific surface markers were identified using immunostaining. It is critical for regulating the activation, maturation, and differentiation of B lymphocytes [2]. CD27 is a memory B lymphocyte marker and is critical for antigen-specific T cell proliferation and memory T cells [3]. Lastly, CD38 is the plasmablast biomarker identified via the BV421 immunostaining. Plasmablasts are immature blood cells that are rapidly proliferated, antibody-secreted B cells that eventually mature into plasma cells.

Figure 1: Schematic of B Cell Activation Process

Methods

Figure 2: Schematic of the Experimental Process

Results

Following confocal imaging, the cells expressing CD27 and CD38 were identified through the use of FITC and BV421 immunostaining, respectively. Their average fluorescence activity of each cell was then measured and compared to one another. For the non-vaccine group, there was an average increase in CD27 intensity by 47 pixels while CD38 decreased on average by only 4 pixels. In contrast, the vaccine group displayed on average an increase in CD27 intensity by 58 pixels and a decrease in CD 38 intensity by 11 pixels.

Figure 3: B Cell Activation Between Non-Vaccine and Vaccine Group for Day 0 and Day 12. Top Row: Non-Vaccine Group. Bottom Row: Vaccine Group

Figure 4: B Cell Activation for Vaccine Groups. Left is Day 0. Right is Day 12.

Using the ImageJ software, the visualization of B lymphocytes is shown using the APC immunostain binding to the CD19 marker on its surface. On Day 0 (left), there were very few B cells as the cells were not yet fully activated. On Day 12 (right), however, the B lymphocytes are highly proliferated as seen by the red circles visible across the area of the chip.

Conclusion

Following the addition of the vaccine to the cells, there was a higher increase of CD27 intensity and decrease of CD38 intensity compared to the non-vaccine group. This verifies that the vaccines are eliciting a greater immune response as more memory B lymphocytes were generated over time and plasmablasts matured into plasma cells.

Future Work

Future experiments will be run with an additional immunostain for the CD20 biomarker. This will ensure a more accurate quantification of B lymphocyte following activation and proliferation. Further along the research process, we hope to pivot from using chips in only vaccine evaluation to being used to observe and quantify the effectiveness of CAR-T therapy on lymphoma.

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[3] Hendriks, J., Gravestein, L., Tesselaar, K. *et al.* CD27 is required for generation and long-term maintenance of T cell immunity . *Nat Immunol* **1**, 433–440 (2000). https://doi.org/10.1038/80877

Acknowledgement

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Improving the Stability of Silver Selenide Quantum Dot Devices for NIR Imaging

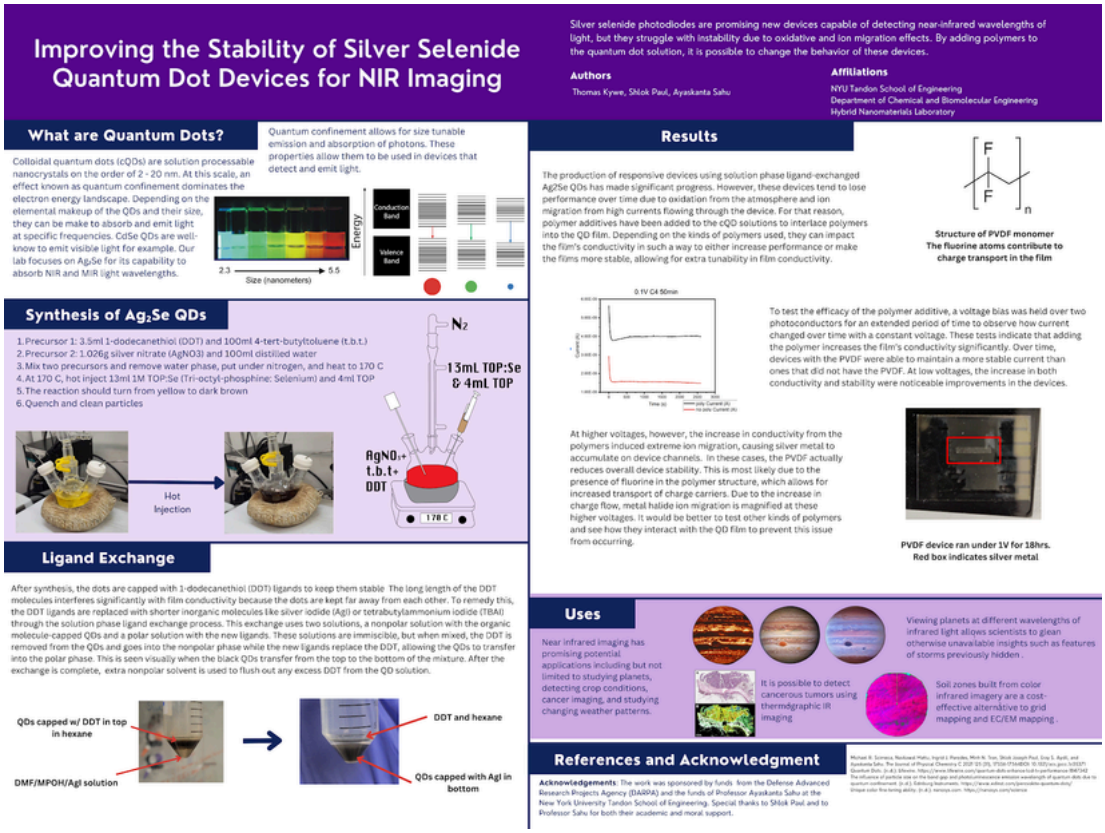
Colloidal quantum dot (CQD) solutions are promising materials for the creation of high-performance and cheap infrared detection and imaging devices. CQDs are small semiconductor nanoparticles that are capable of absorbing light within a specific wavelength range. Commonly, CQDs are dispersed in solutions that can be deposited into films capable of generating detectable currents that can be used as part of larger circuits. These devices can be used for a variety of purposes, like temperature and weather monitoring, evaluating crop quality, cancer imaging, and much more. Currently, the efficacy of CQD devices is limited due to their relatively short longevity. Under strong electric fields and extended exposure to atmospheric conditions, the CQD film quality will deteriorate due to electric field-induced ion migration and oxidation, causing the readings from the device to be more unstable and unreliable. This project aims to improve the stability of silver selenide (Ag2Se) films by introducing different polymers into the CQD solutions in order to change how ions flow throughout the material. Depending on the polymer used, it is possible to tune the ion flow to create either more conductive devices or more stable devices. We hope to optimize the tunability of ion migration within Ag2Se devices to create more efficient and longer-lasting detectors.

Project Supervisor Ayaskanta Sahu

Research Areas Health



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NYU Tandon



Develop an Experience Sampling Tool for MS Healthcare Research

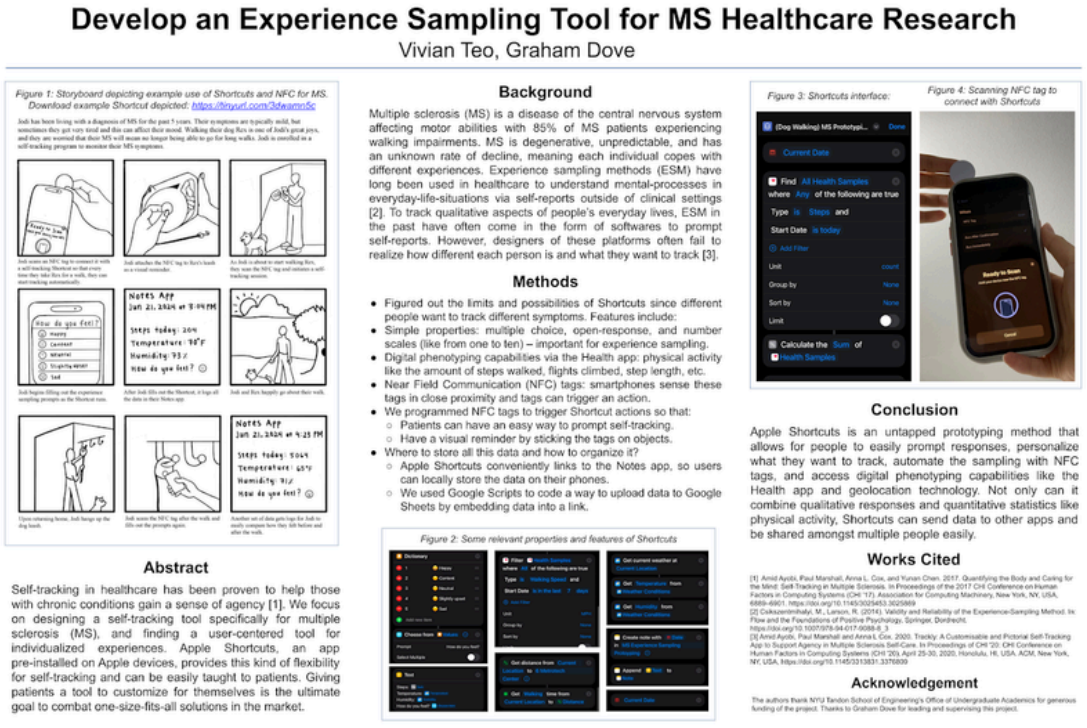
Self-tracking in healthcare has been proven to help those with chronic conditions gain a sense of agency. We focus on designing a self-tracking tool with experience sampling specifically for multiple sclerosis (MS), a disease of the central nervous system affecting motor abilities with 85% of MS patients experiencing walking impairments. MS is known to be degenerative, unpredictable, and have an unknown rate of decline, meaning each individual copes with different experiences. Experience sampling methods in the past have often come in the form of software applications asking questions and prompting responses, but our research focuses on finding a user-centered and customizable tool for individualized experiences. Apple Shortcuts is an untapped prototyping method that allows for people to easily prompt responses, personalize what they want to track, automate the sampling with NFC tags, and access digital phenotyping capabilities like the Health app and geolocation technology. Not only can it combine qualitative responses and quantitative statistics like physical activity, Shortcuts can send data to other apps and be shared amongst multiple people easily. It's important to note that self-tracking is a consistent task that can serve as a constant reminder of having MS, contributing to worsening mental health. For those who partake in self-tracking, there must be a balance between the task becoming burdensome versus taking advantage of its benefits. Giving patients a tool to customize for themselves is the ultimate goal to combat one-size-fits-all solutions in the market and allow them that flexibility to balance the benefits of self-tracking.

Project Supervisor Graham Dove

Research Areas Health



Vivian Teo
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Tandon Scholars Fellowship



Develop an Experience Sampling Tool for MS Healthcare Research

Vivian Teo, Graham Dove

Figure 1: Storyboard depicting example use of Shortcuts and NFC for MS. Download example Shortcut depicted: https://tinyurl.com/3dwamn5c

Abstract

Self-tracking in healthcare has been proven to help those with chronic conditions gain a sense of agency [1]. We focus on designing a self-tracking tool specifically for multiple sclerosis (MS), and finding a user-centered tool for individualized experiences. Apple Shortcuts, an app pre-installed on Apple devices, provides this kind of flexibility for self-tracking and can be easily taught to patients. Giving patients a tool to customize for themselves is the ultimate goal to combat one-size-fits-all solutions in the market.

Background

Multiple sclerosis (MS) is a disease of the central nervous system affecting motor abilities with 85% of MS patients experiencing walking impairments. MS is degenerative, unpredictable, and has an unknown rate of decline, meaning each individual copes with different experiences. Experience sampling methods (ESM) have long been used in healthcare to understand mental-processes in everyday-life-situations via self-reports outside of clinical settings [2]. To track qualitative aspects of people's everyday lives, ESM in the past have often come in the form of softwares to prompt self-reports. However, designers of these platforms often fail to realize how different each person is and what they want to track [3].

Methods

- Figured out the limits and possibilities of Shortcuts since different people want to track different symptoms. Features include:
- Simple properties: multiple choice, open-response, and number scales (like from one to ten) – important for experience sampling.
- Digital phenotyping capabilities via the Health app: physical activity like the amount of steps walked, flights climbed, step length, etc.
- Near Field Communication (NFC) tags: smartphones sense these tags in close proximity and tags can trigger an action.
- We programmed NFC tags to trigger Shortcut actions so that:
  - Patients can have an easy way to prompt self-tracking.
  - Have a visual reminder by sticking the tags on objects.
- Where to store all this data and how to organize it?
  - Apple Shortcuts conveniently links to the Notes app, so users can locally store the data on their phones.
  - We used Google Scripts to code a way to upload data to Google Sheets by embedding data into a link.

Figure 2: Some relevant properties and features of Shortcuts

Figure 3: Shortcuts interface:

Figure 4: Scanning NFC tag to connect with Shortcuts

Conclusion

Apple Shortcuts is an untapped prototyping method that allows for people to easily prompt responses, personalize what they want to track, automate the sampling with NFC tags, and access digital phenotyping capabilities like the Health app and geolocation technology. Not only can it combine qualitative responses and quantitative statistics like physical activity, Shortcuts can send data to other apps and be shared amongst multiple people easily.

Works Cited

Acknowledgement

Leveraging Non-Viral Supercharged Protein Coiled-coil Protein with Viral Infiltration Tags for siRNA Delivery: Endosomal Escape for Lipoproteoplexes with minimal Toxicity

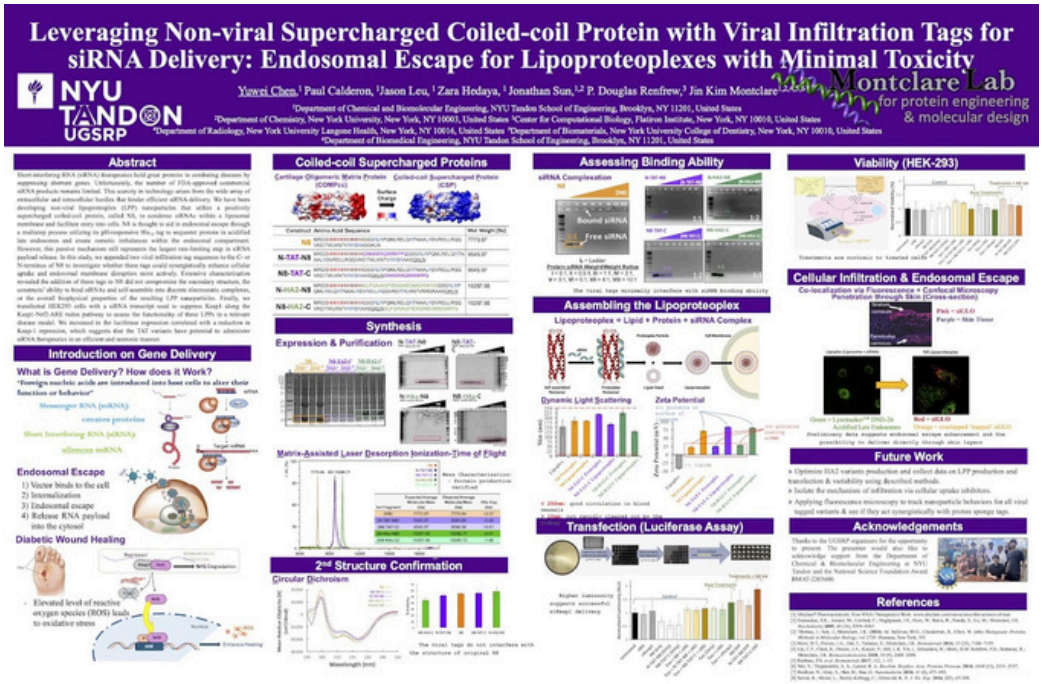
Short-interfering RNA (siRNA) therapeutics hold great promise in combating diseases by suppressing aberrant genes. Unfortunately, the number of FDA-approved commercial siRNA products remains limited. This scarcity in technology arises from the wide array of extracellular and intracellular hurdles that hinder efficient siRNA delivery. We have been developing non-viral lipoproteoplex (LPP) nanoparticles that utilize a positively supercharged coiled-coil protein, called N8, to condense siRNAs within a liposomal membrane and facilitate entry into cells. N8 is thought to aid in endosomal escape through a multistep process utilizing its pH-responsive His tag to sequester protons in acidified late endosomes and create osmotic imbalances within the endosomal compartment. However, this passive mechanism still represents the largest rate-limiting step in siRNA payload release. In this study, we appended two viral infiltration tag sequences to the C- or N-terminus of N8 to investigate whether these tags could synergistically enhance cellular uptake and endosomal membrane disruption more actively. Extensive characterization revealed the addition of these tags to N8 did not compromise the secondary structure, the constructs' ability to bind siRNAs and self-assemble into discrete electrostatic complexes, or the overall biophysical properties of the resulting LPP nanoparticles. Finally, we transfected HEK293 cells with a siRNA transcript used to suppress Keap1 along the Keap1-Nrf2-ARE redox pathway to assess the functionality of these LPPs in a relevant disease model. We increased in the luciferase expression correlated with a reduction in Keap-1 repression, which suggests that the TAT variants have potential to administer siRNA therapeutics in an efficient and nontoxic manner.

Project Supervisor Jin Montclare

Research Areas Health



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Pinkerton Lab

Project Supervisor Nathalie Pinkerton

Research Staff Amy Moreno, Kiana Bahrami, Rachel Pollard



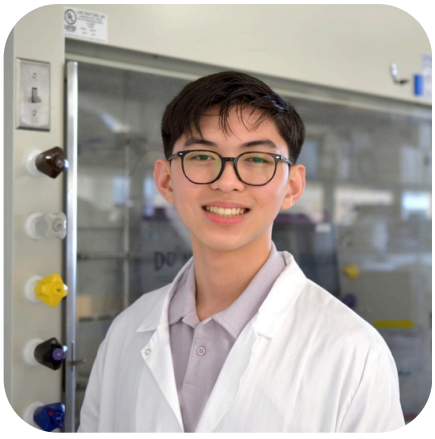
Steven Martinez
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Xiuxian Li
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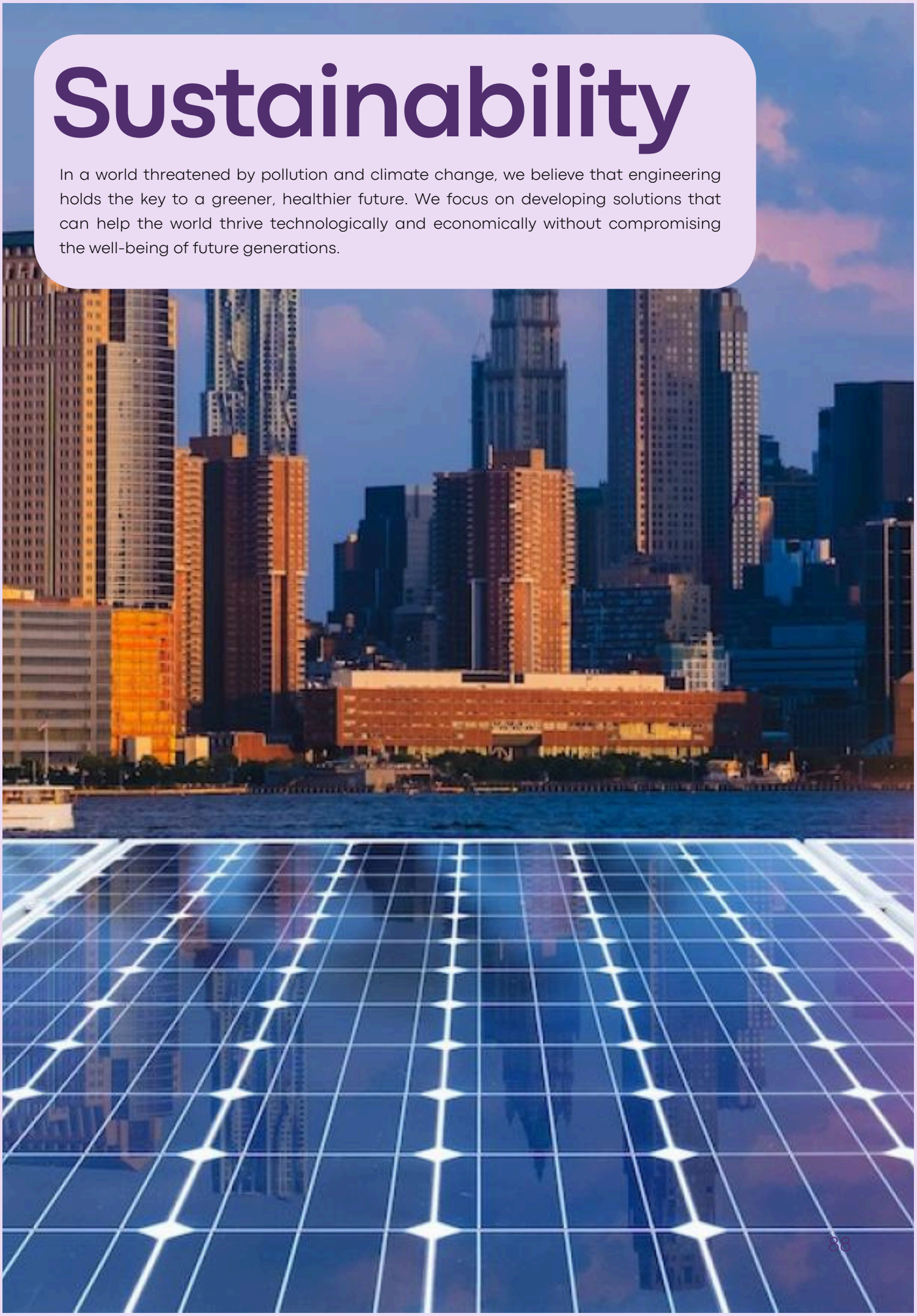
Jessica, Lab Manager
In front of the Pump Systems



Mahan Gillin
Inspecting the cover glass to be bonded to the microfluidic chip

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.



The Impact of Color Temperature and Color Rendering Index on Indoor Solar Cell Design for IoT Applications

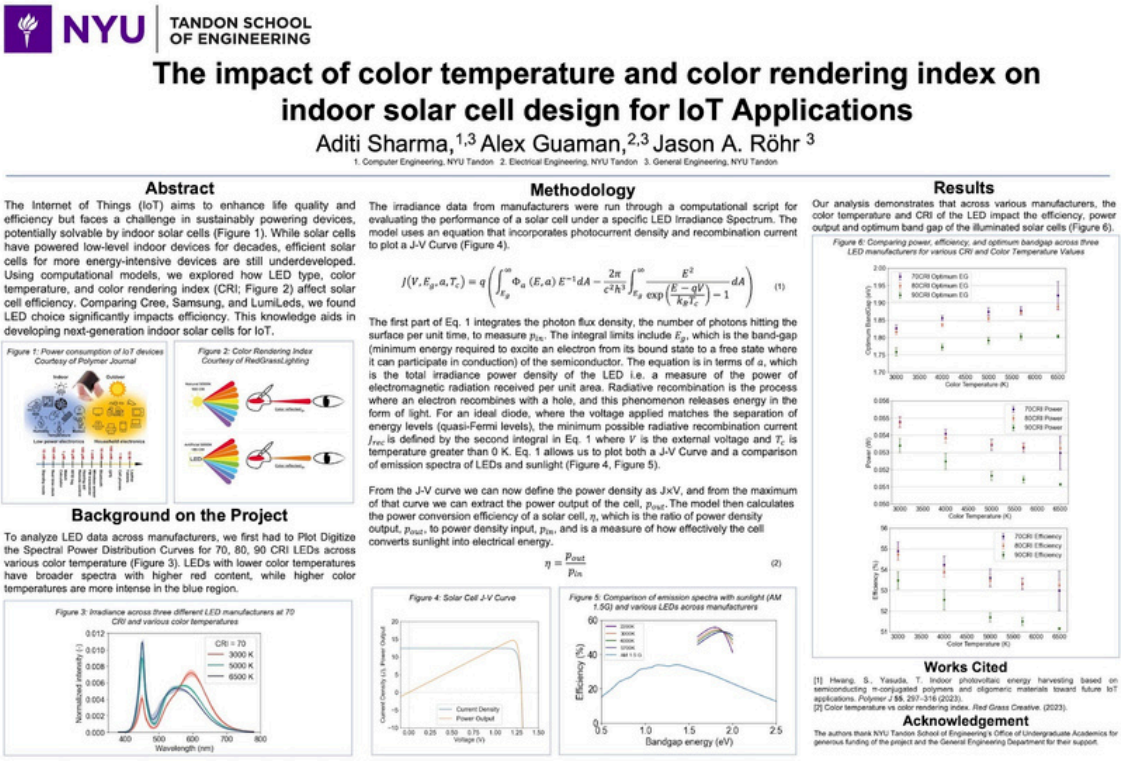
The Internet of Things (IoT) encompasses the communication between consumer electronics, wearable devices, wireless sensors, and smart meters, aiming to enhance quality of life and efficiency across various activities. However, the rapid expansion of the IoT ecosystem, now comprising tens of billions of units, presents a challenge in sustainably powering these devices. This energy powering challenge could potentially be solved by solar cells. Solar cells have been used to power low-level indoor devices such as pocket calculators for many decades; however, the development of highly efficient solar cells for more energy intensive indoor devices is still in its infancy. The challenge arises partly from limited knowledge about the requirements for light-absorbing and power-generating semiconductors in indoor solar cells. Using computational models, we explored how the choice of indoor LED type, color temperature, and color rendering index, impacts the fundamental factors governing charge generation and power output of solar cells. We compared and contrasted LED irradiance data across three different manufacturers, namely Cree, Samsung, and LumiLeds. Our findings demonstrate that the color temperature and color rendering index of the LED impact the efficiency, power output and optimum band gap of the illuminated solar cells. Thus, the choice of LED used for indoor lighting is significant when designing indoor solar cell devices. This knowledge will aid solar cell engineers and scientists in developing next-generation indoor cells for powering an ever-growing IoT.

Project Supervisor Jason Röhr

Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

The impact of color temperature and color rendering index on indoor solar cell design for IoT Applications

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1. Computer Engineering, NYU Tandon 2. Electrical Engineering, NYU Tandon 3. General Engineering, NYU Tandon

Abstract

The Internet of Things (IoT) aims to enhance life quality and efficiency but faces a challenge in sustainably powering devices, potentially solvable by indoor solar cells (Figure 1). While solar cells have powered low-level indoor devices for decades, efficient solar cells for more energy-intensive devices are still underdeveloped. Using computational models, we explored how LED type, color temperature, and color rendering index (CRI; Figure 2) affect solar cell efficiency. Comparing Cree, Samsung, and LumiLeds, we found LED choice significantly impacts efficiency. This knowledge aids in developing next-generation indoor solar cells for IoT.

Figure 1: Power consumption of IoT devices Courtesy of Polymer Journal

Figure 2: Color Rendering Index Courtesy of RedGrassLighting

Background on the Project

To analyze LED data across manufacturers, we first had to Plot Digitize the Spectral Power Distribution Curves for 70, 80, 90 CRI LEDs across various color temperature (Figure 3). LEDs with lower color temperatures have broader spectra with higher red content, while higher color temperatures are more intense in the blue region.

Figure 3: Irradiance across three different LED manufacturers at 70 CRI and various color temperatures

Methodology

The irradiance data from manufacturers were run through a computational script for evaluating the performance of a solar cell under a specific LED Irradiance Spectrum. The model uses an equation that incorporates photocurrent density and recombination current to plot a J-V Curve (Figure 4).

$$J(V,E_g,a,T_c) = q\left(\int_{E_g}^{\infty}\Phi_a(E,a)\,E^{-1}dA - \frac{2\pi}{c^2h^3}\int_{E_g}^{\infty}\frac{E^2}{\exp\left(\frac{E-qV}{k_BT_c}\right)-1}dA\right) \quad (1)$$

The first part of Eq. 1 integrates the photon flux density, the number of photons hitting the surface per unit time, to measure p_{in}. The integral limits include E_g, which is the band-gap (minimum energy required to excite an electron from its bound state to a free state where it can participate in conduction) of the semiconductor. The equation is in terms of a, which is the total irradiance power density of the LED i.e. a measure of the power of electromagnetic radiation received per unit area. Radiative recombination is the process where an electron recombines with a hole, and this phenomenon releases energy in the form of light. For an ideal diode, where the voltage applied matches the separation of energy levels (quasi-Fermi levels), the minimum possible radiative recombination current J_{rec} is defined by the second integral in Eq. 1 where V is the external voltage and T_c is temperature greater than 0 K. Eq. 1 allows us to plot both a J-V Curve and a comparison of emission spectra of LEDs and sunlight (Figure 4, Figure 5).

From the J-V curve we can now define the power density as J×V, and from the maximum of that curve we can extract the power output of the cell, p_{out}. The model then calculates the power conversion efficiency of a solar cell, η, which is the ratio of power density output, p_{out}, to power density input, p_{in}, and is a measure of how effectively the cell converts sunlight into electrical energy.

$$\eta = \frac{P_{out}}{P_{in}} \quad (2)$$

Figure 4: Solar Cell J-V Curve

Figure 5: Comparison of emission spectra with sunlight (AM 1.5G) and various LEDs across manufacturers

Results

Our analysis demonstrates that across various manufacturers, the color temperature and CRI of the LED impact the efficiency, power output and optimum band gap of the illuminated solar cells (Figure 6).

Figure 6: Comparing power, efficiency, and optimum bandgap across three LED manufacturers for various CRI and Color Temperature Values

Works Cited

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project and the General Engineering Department for their support.

Characterizing Amyloid Aggregation of Pyrococcus Furiosus B-Glucosidase

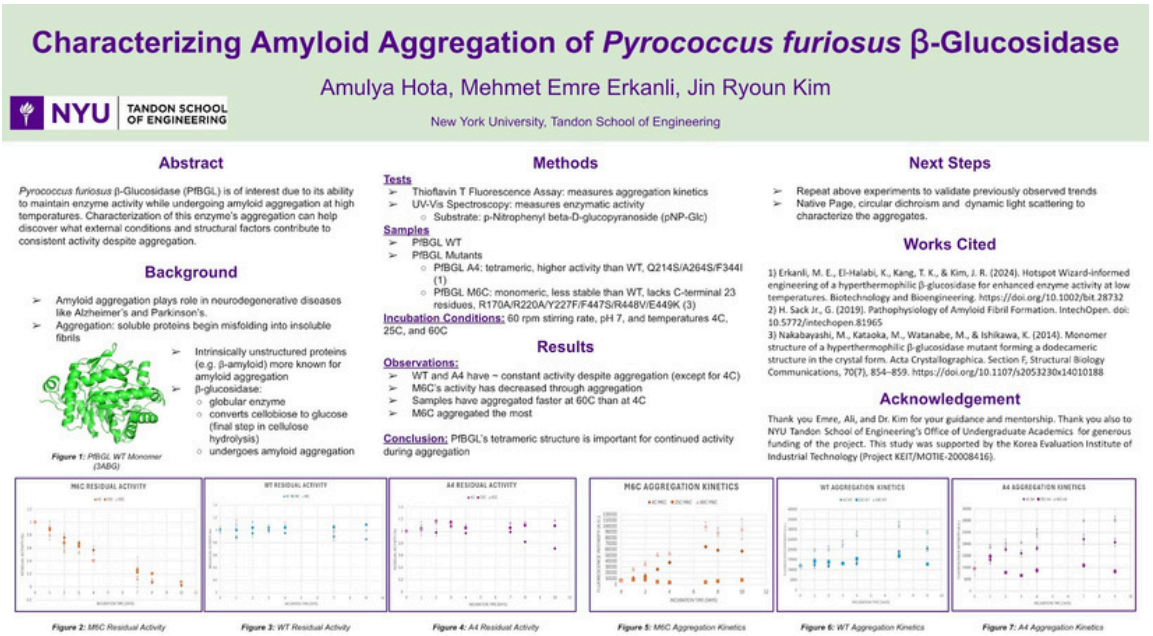
Amyloid aggregation has been an area of high research interest over the past few decades due to the role it plays in neurodegenerative diseases like Alzheimer's and Parkinson's. Aggregation occurs when soluble proteins begin misfolding into insoluble fibrils. While intrinsically unstructured proteins (like β-amyloid) are more known for amyloid aggregation, globular proteins are just as capable of aggregation. β-glucosidase, an enzyme responsible for converting cellobiose to glucose (final step in cellulose hydrolysis), is one of the globular enzymes capable of amyloid aggregation. Pyrococcus furiosus β-Glucosidase (PfBGL) is of interest due to its ability to maintain enzyme activity while undergoing amyloid aggregation at high temperatures. Characterization of this enzyme's aggregation can help discover what external conditions and structural factors contribute to consistent activity despite aggregation. Characterization methods include thioflavin T fluorescence assay to measure aggregation kinetics, UV-Vis spectroscopy with p-Nitrophenyl beta-D-glucopyranoside (pNP-Glc) substrate to measure enzyme activity, and circular dichroism to measure the enzyme's secondary structure and stability. These tests were carried out on PfBGL wild type (WT) and two mutants, A4 (tetrameric, higher activity than WT, Q214S/A264S/F344I) and M6C (monomeric, less stable than WT, lacks C-terminal 23 residues, R170A/R220A/Y227F/F447S/R448V/E449K), which were incubated at 60 rpm stirring rate, pH 7, and temperatures 4C, 25C, and 60C. PfBGL WT and A4 have maintained almost constant activity despite aggregation. In comparison, M6C's activity has decreased while aggregating, indicating that the tetrameric structure of PfBGL is important for continued activity during aggregation. Additionally, the samples have aggregated faster at 60C compared to 25C. Next, the above experiments will be repeated to validate previously observed trends. Native Page and DLS will be conducted to measure the aggregating enzyme's size.

Project Supervisor Ali Malli, Emre Erkanli

Research Areas Sustainability



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Characterizing Amyloid Aggregation of *Pyrococcus furiosus* β-Glucosidase

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NYU TANDON SCHOOL OF ENGINEERING

New York University, Tandon School of Engineering

Abstract

Pyrococcus furiosus β-Glucosidase (PfBGL) is of interest due to its ability to maintain enzyme activity while undergoing amyloid aggregation at high temperatures. Characterization of this enzyme's aggregation can help discover what external conditions and structural factors contribute to consistent activity despite aggregation.

Background

- Amyloid aggregation plays role in neurodegenerative diseases like Alzheimer's and Parkinson's.
- Aggregation: soluble proteins begin misfolding into insoluble fibrils

Figure 1: PfBGL WT Monomer (3ABG)

- Intrinsically unstructured proteins (e.g. β-amyloid) more known for amyloid aggregation
- β-glucosidase:
  - globular enzyme
  - converts cellobiose to glucose (final step in cellulose hydrolysis)
  - undergoes amyloid aggregation

Methods

Tests
- Thioflavin T Fluorescence Assay: measures aggregation kinetics
- UV-Vis Spectroscopy: measures enzymatic activity
  - Substrate: p-Nitrophenyl beta-D-glucopyranoside (pNP-Glc)

Samples
- PfBGL WT
- PfBGL Mutants
  - PfBGL A4: tetrameric, higher activity than WT, Q214S/A264S/F344I (1)
  - PfBGL M6C: monomeric, less stable than WT, lacks C-terminal 23 residues, R170A/R220A/Y227F/F447S/R448V/E449K (3)

Incubation Conditions: 60 rpm stirring rate, pH 7, and temperatures 4C, 25C, and 60C

Results

Observations:
- WT and A4 have ~ constant activity despite aggregation (except for 4C)
- M6C's activity has decreased through aggregation
- Samples have aggregated faster at 60C than at 4C
- M6C aggregated the most

Conclusion: PfBGL's tetrameric structure is important for continued activity during aggregation

Next Steps

- Repeat above experiments to validate previously observed trends
- Native Page, circular dichroism and dynamic light scattering to characterize the aggregates.

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Acknowledgement

Thank you Emre, Ali, and Dr. Kim for your guidance and mentorship. Thank you also to NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. This study was supported by the Korea Evaluation Institute of Industrial Technology (Project KEIT/MOTIE-20008416).

Figure 2: M6C Residual Activity | Figure 3: WT Residual Activity | Figure 4: A4 Residual Activity | Figure 5: M6C Aggregation Kinetics | Figure 6: WT Aggregation Kinetics | Figure 7: A4 Aggregation Kinetics

Thermo-Control System for Nikon Optical Microscope

Small-angle light scattering (SALS) and Polarized Optical Microscopy (POM) are techniques used to study the structure and optical properties of materials on a microscopic scale. Both require stable and precise control systems, especially for temperature regulation, to ensure accurate measurements. Although feedback control systems typically automate this process, our setup requires manual adjustments and is inefficient. We initially purchased a control system for the Nikon Eclipse E400 POL microscope used in POM, but it was incompatible with the custom canister from UC Berkeley used in our scattering experiments. To mitigate these issues and reduce costs, I began developing a thermo-control system for the microscope. I custom-designed and 3D-printed a heating unit using Fusion360 to hold the lithium sample canister. The model, printed at NYU Tandon Makerspace, cost $1 to produce and took 30 minutes to print, with a total expenditure of $12. The design is cost-efficient, sustainable, and easily replaceable, requiring minimal ABS plastic. For control, I modeled the system in SOLIDWORKS and simulated the temperature controller using Simulink, which allows dynamic system modeling. The next step is to integrate the 3D model with the simulation and power it through Arduino, enabling testing and fine-tuning of the system's parameters once set up. This research not only optimizes experimental efficiency but also provides a scalable, cost-effective solution for custom-designing applications in light scattering experiments.

Project Supervisor Xin Wang

Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

Thermo-Control System for Nikon Optical Microscope

Angie Mohamed
PI: Xin Wang, Department of Chemical and Biomolecular Engineering

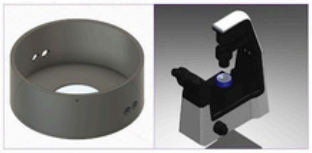
Abstract

Small-angle light scattering (SALS) and Polarized Optical Microscopy (POM) are methods used to observe the optical properties of materials. In the control systems involved in SALS and POM, feedback systems monitor the sample temperature and adjust it to maintain the desired setpoint. However, our control system requires manual temperature adjustments and needs to be more efficient. I have worked on the initial stages of developing a thermo-control system for the Nikon optical microscope, Eclipse E400 POL. To address this, I designed and 3D-printed a model for the heating unit using Fusion360 and modeled the control system in Simulink. My next steps are to connect the control system to power by building the controller, setting certain parameters in the model, and testing the system.

Background on the Project

For SALS and POM, temperature control is a main objective, monitoring and adjusting to maintain the desired sample temperature is crucial. However, our control system requires manual temperature adjustments. Originally a control system had been purchased from a company to address this, which was expensive and the part measurements were incorrect. The manufacturing company also had poor communication with our lab. Time and money were lost waiting for the right equipment, which is why this lab has chosen to custom-design the control system.

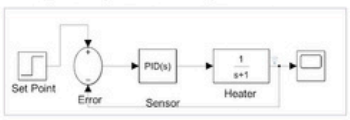
Figure 1: 3D-printed Design created in Fusion360 (left) modeled on microscope in Solidworks (right)



Materials and Methods

I have been developing a thermo-control system by first custom-designing a part to hold our sample in Fusion360 (Figure 1). Then, 3D-printing the model in the Makerspace using ABS plastic and modeled the graphics of control system in Solidworks (Figure 1). The 3D-printed model was made to fit on the microscope, with enough room to fit a thermocouple. I designed the PID temperature control system in Simulink (Figure 3).

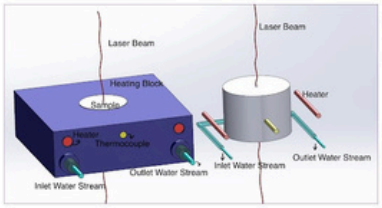
Figure 2: Temperature PID control system on Simulink



Applications & Next Steps

I have modeled our system here on SolidWorks (Figure 3) and have started building our control system on Simulink. My next step is to connect the 3D model to the Simulink simulation and power by building the controller using Arduino. I will also adjust the parameters and test the control system until the system error is desirable.

Figure 3: Control System Modeled on Solidworks



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Acknowledgment

The author thanks NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project, along with Professor Wang

Analysis of Ion Diffusivities in Fast Charging Lithium Ion Batteries

Lithium-ion batteries dominate the market due to their high energy density, stability, and longevity. Among these, $LiMn_2O_4$ (LMO) and $Li_4Ti_5O_{12}$ (LTO) are notable materials. LMO is valued for its high voltage and cost-effectiveness, while LTO is known for its excellent safety profile and long cycle life. This study aims to develop a protocol for estimating electrode performance based on ion diffusivity. Specifically, we focus on LMO/LTO full cells, whose performance is influenced by electrode loading and electrolyte concentration.

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Research Areas Sustainability
Research Staff Yaxin Shen



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Analysis of Ion Diffusivities in Fast Charging Lithium-Ion Batteries

NYU TANDON SCHOOL OF ENGINEERING — Transformative Materials & Devices Lab

Ariel Suynov[1], Yaxin Shen[1], André Taylor[1]

Background

The diffusion coefficient, or ion diffusivity of Lithium-Ion batteries is a crucial parameter used to characterize Lithium migration within the cell. Knowing this value for the charge and discharge processes paves the way to attaining the molar flux of Li^+ ions at the anode and cathode surfaces. A significant variation of these values suggests that Li^+ ions are getting absorbed elsewhere, such as by the electrolyte or a side reaction, thus reducing the effectiveness of the battery. Ultimately, knowing the Li^+ ion diffusivities and their trends is the first step in troubleshooting and improving the cell. In this work, diffusivities are computed via Cyclic Voltammetry (CV), using the Randles-Sevcik correlation (**equation 1**), and via Galvanostatic Intermittent Titration Technique (GITT), using a correlation developed by Weppner and Huggins[2] (**equation 2**):

$$i_p = 0.4463nFAC\sqrt{\frac{nFvD}{RT}} \quad (1); D = \frac{4}{\pi}\left(\frac{V_M}{SFz_i}\right)^2\left(I_0\left(\frac{dE}{d\delta}\right)/\left(\frac{dE}{d\sqrt{t}}\right)\right)^2 \quad (2)$$

Methods

For this work, we will assemble $LiMn_2O_4/Li_4Ti_5O_{12}$ (LMO/LTO) full cells outlined by the process shown in Figure 1:

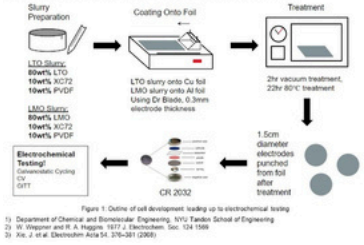


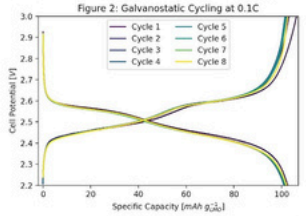
Figure 1: Outline of cell development leading up to electrochemical testing

1) Department of Chemical and Biomolecular Engineering, NYU Tandon School of Engineering
2) W. Weppner and R. A. Huggins 1977 J. Electrochem. Soc. 124 1569
3) Xie, J. et al. Electrochim Acta 54, 376–381 (2008)

Results

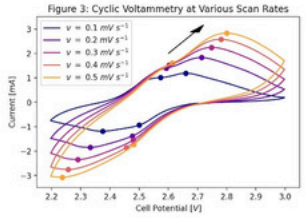
8 galvanostatic cycles at 0.1C was administered to ensure adequate solid electrolyte interphase (SEI) layer formation and electrode stabilization for long term use before running CV.

Figure 2: Galvanostatic Cycling at 0.1C



CV was run at several scan rates, with the peak points outlined:

Figure 3: Cyclic Voltammetry at Various Scan Rates



Each charge/discharge cycle yields two peaks each, reflecting LMO's two-step lithiation/delithiation mechanism. The diffusivity for each step is measured using the Randles-Sevcik correlation from peak currents i_p after baseline subtraction to remove non-faradaic influences.

Figure 4: Employing Randles-Sevcik Correlation to Compute D at All Steps

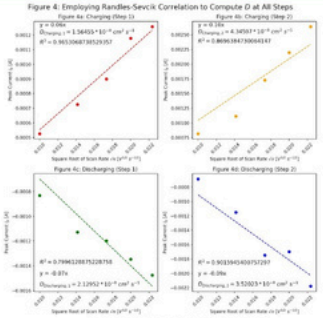
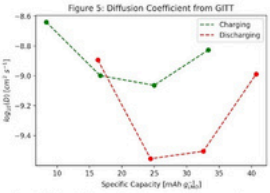


Figure 5: Diffusion Coefficient from GITT



D values from CV are bigger for the second step ($0.5 \leq x \leq 1$ in $Li_{1-x}Mn_2O_4$), indicative of faster ion transport during that stage. GITT shows an initial decrease in D, followed by a gradual increase. This trend is consistent with results from Xie et al.[3], postulating that it is due to lattice shrinkage/expansion due to Li^+ ion intercalation/extraction.

Photodegradation of Antibiotic-Resistant Gene ampR and Bacteria E.faecalis in Wastewater

In wastewater systems, extracellular antibiotic resistance genes (eARGs) can propagate through bacteria, significantly threatening public health through the spread and development of antibiotic resistant bacteria (ARB). A potential countermeasure to this propagation is to damage the eARGs and bacteria using natural sunlight or ultraviolet radiation. Understanding photodegradation could provide a new way to reduce eARG and ARB prevalence in the environment, potentially mitigating the spread of antibiotic resistance.

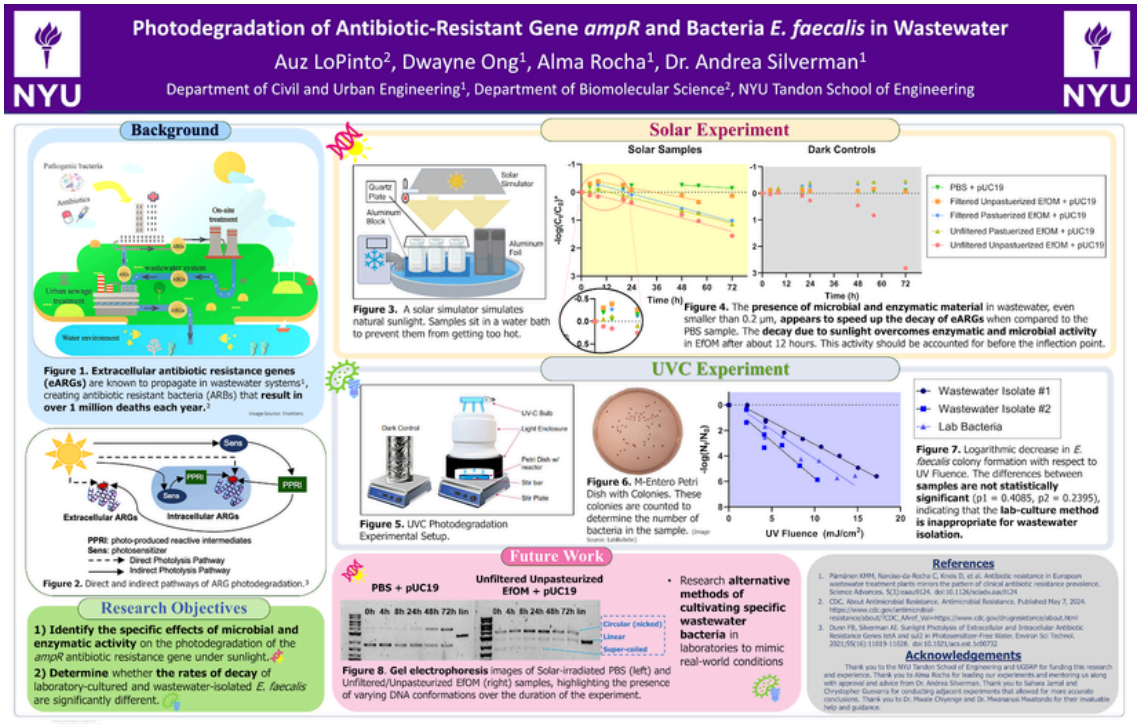
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CuSe and NiSe2 Nanocatalysts for CO2 Electrochemical Reduction

Electrocatalytic CO2 reduction is a promising path for not only lowering CO2 levels in the atmosphere, but also making useful organic products. The process is relatively simple and consumes less energy than other methods of CO2 reduction. While research has shown good selectivity with noble metals catalysts, the biggest drawback is their cost. As such, transition metal chalcogenides (TMCs) have received significant attention because of their promising results as inexpensive catalytic alternatives to noble metals. In addition, TMCs can be made as two-dimensional (2-D) structures on the nanoscale. These nanoscale catalysts seem to be more active than their bulk counterparts. To find a selective catalyst, two transition metal selenides were tested: CuSe nanosheets and NiSe2 nanocubes. This was done in a small electrochemical reactor with dilute sulfuric acid. The solution in the reactor was then analyzed using NMR and the gas evolved from the reaction was collected. These findings could potentially be useful in choosing the right compound, nanostructure, and conditions to reduce CO2 into desired products.

Project Supervisor Ayaskanta Sahu

Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

CuSe and $NiSe_2$ Nanocatalysts for CO_2 Electrochemical Reduction

Cayden Auyeung, Hao Xian Zheng, Ayaskanta Sahu

Introduction

CO_2 levels are rising at an alarming rate, leading to climate problems and negative impacts on people's health around the globe.

Electrocatalytic CO_2 reduction is seen a promising path for not only lowering CO_2 levels in the atmosphere, but also making useful organic products.

Research has been done on noble metals as catalysts to reduce CO_2, but they've shown low activity past reduction into CO and have high costs [1].

As such, transition metal selenides chalcogenides have been shown great interest as alternate more active, less expensive catalysts.

This project investigates two transition metal selenides, CuSe nanosheets and NiSe2 nanocubes, in order to find a catalyst that fit as many of the following criteria as possible: 1) high selectivity, 2) high faradaic efficiency, 3) low overpotentials.

Methodology

The CuSe nanosheets and $NiSe_2$ nanocubes were synthesized, according to procedures of other experimentalists [2, 3].

The samples were verified using scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM-EDS).

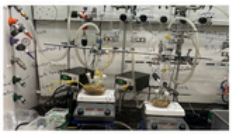


Image 1: Nanomaterial Synthesis Apparatus

The nanostructures were tested in a reaction chamber with 0.5 M H_2SO_4 solution at different voltages. Note: These voltages are being compared to the standard Ag/AgCl electrode.

The products in solution were identified using NMR, and gaseous products were collected in a sampling bag.

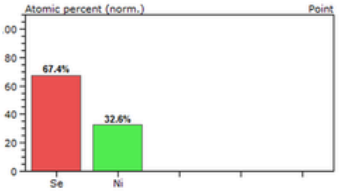


Figure 1: $NiSe_2$ SEM-EDS Percent Elemental Composition Data

Results and Data

$$\text{Faradaic efficiency}(\text{FE}) = \frac{nZF}{Q}$$

Faradaic efficiency is the ratio of the amount of product detected experimentally to the amount theoretically. F is the Faraday constant (96,485 C/mol), n is the amount of product in moles, Q is the total amount of charge passed through, and Z is the amount of electrons needed to produce one molecule of product.

At a potential of -2 V, both the CuSe nanosheets and $NiSe_2$ nanocubes had high selectivity and high FE.

The $NiSe_2$ had a 99.6% FE for producing ethylene glycol, while CuSe had a 96.45% FE for producing gas products. This mixture of gases is likely a mixture of C_1 and C_2 gases like methane and ethane [4]

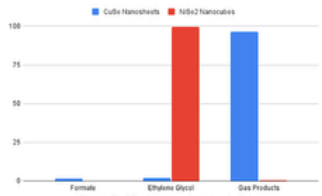


Figure 2: FE of Nanocatalysts at -2V

Conclusion

These results provide good steps towards a world where we can capture CO_2 and turn it into useful products. Next steps include more research into these and other materials, and structures to make the system more efficient by reducing applied overpotentials.

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Co-developing Underwater and Indoor Solar Panels for IoT Applications

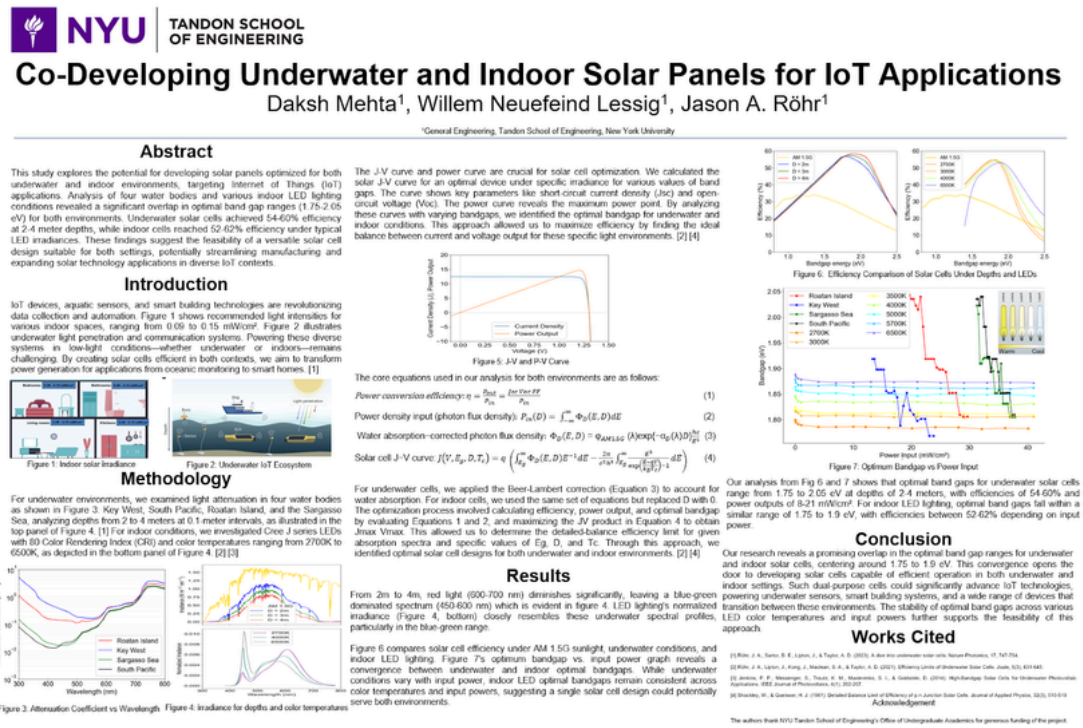
This research project explores the potential for co-developing solar panels optimized for both underwater and indoor environments, with applications in Internet of Things (IoT) industries. Underwater solar cells face unique challenges, as water absorbs much of the red part of the solar spectrum, necessitating designs that efficiently capture blue and green wavelengths. Our analysis of four different water bodies reveals that optimal bandgaps for underwater solar cells range from 1.75 to 2.05 eV at depths of 2-4 meters, with efficiencies of 54-60% and power outputs of 8-21 mW/cm². For indoor applications, we examined Cree J series LEDs with a color rendering index (CRI) of 80 and color temperatures between 2700K and 6500K. The optimal bandgap for these indoor conditions ranges from 1.75 to 1.9 eV, with efficiencies of 52-62% depending on input power. Notably, the optimal band gap remains constant across a wide range of input irradiance levels, including the typical 0.1 mW/cm² for indoor LEDs. Our findings reveal a significant overlap in the optimal band gap ranges for underwater and indoor solar cells. This convergence suggests the feasibility of developing a single solar cell design suitable for both environments. Such versatility could streamline manufacturing processes and expand the applications of solar technology in IoT and other industries requiring reliable power sources in diverse settings.

Project Supervisor Jason Röhr

Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

Co-Developing Underwater and Indoor Solar Panels for IoT Applications

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[1]General Engineering, Tandon School of Engineering, New York University

Abstract

This study explores the potential for developing solar panels optimized for both underwater and indoor environments, targeting Internet of Things (IoT) applications. Analysis of four water bodies and various indoor LED lighting conditions revealed a significant overlap in optimal band gap ranges (1.75-2.05 eV) for both environments. Underwater solar cells achieved 54-60% efficiency at 2-4 meter depths, while indoor cells reached 52-62% efficiency under typical LED irradiances. These findings suggest the feasibility of a versatile solar cell design suitable for both settings, potentially streamlining manufacturing and expanding solar technology applications in diverse IoT contexts.

Introduction

IoT devices, aquatic sensors, and smart building technologies are revolutionizing data collection and automation. Figure 1 shows recommended light intensities for various indoor spaces, ranging from 0.09 to 0.15 mW/cm². Figure 2 illustrates underwater light penetration and communication systems. Powering these diverse systems in low-light conditions—whether underwater or indoors—remains challenging. By creating solar cells efficient in both contexts, we aim to transform power generation for applications from oceanic monitoring to smart homes. [1]

Figure 1: Indoor solar irradiance

Figure 2: Underwater IoT Ecosystem

Methodology

For underwater environments, we examined light attenuation in four water bodies as shown in Figure 3: Key West, South Pacific, Roatan Island, and the Sargasso Sea, analyzing depths from 2 to 4 meters at 0.1-meter intervals, as illustrated in the top panel of Figure 4. [1] For indoor conditions, we investigated Cree J series LEDs with 80 Color Rendering Index (CRI) and color temperatures ranging from 2700K to 6500K, as depicted in the bottom panel of Figure 4. [2] [3]

Figure 3: Attenuation Coefficient vs Wavelength

Figure 4: Irradiance for depths and color temperatures

The J-V curve and power curve are crucial for solar cell optimization. We calculated the solar J-V curve for an optimal device under specific irradiance for various values of band gaps. The curve shows key parameters like short-circuit current density (Jsc) and open-circuit voltage (Voc). The power curve reveals the maximum power point. By analyzing these curves with varying bandgaps, we identified the optimal bandgap for underwater and indoor conditions. This approach allowed us to maximize efficiency by finding the ideal balance between current and voltage output for these specific light environments. [2] [4]

Figure 5: J-V and P-V Curve

The core equations used in our analysis for both environments are as follows:

$$\text{Power conversion efficiency: } \eta = \frac{P_{out}}{P_{in}} = \frac{J_{mp} V_{mp} FF}{P_{in}} \quad (1)$$

$$\text{Power density input (photon flux density): } P_{in}(D) = \int_{-\infty}^{\infty} \Phi_D(E,D)\,dE \quad (2)$$

$$\text{Water absorption-corrected photon flux density: } \Phi_D(E,D) = \varphi_{AM1.5G}(\lambda)\exp\{-\alpha_D(\lambda)D\}\frac{hc}{E} \quad (3)$$

$$\text{Solar cell J-V curve: } J(V,E_g,D,T_c) = q\left(\int_{E_g}^{\infty}\Phi_D(E,D)E^{-1}dE - \frac{2\pi}{c^2h^3}\int_{E_g}^{\infty}\frac{E^2}{\exp\left(\frac{E-qV}{k_BT_c}\right)-1}dE\right) \quad (4)$$

For underwater cells, we applied the Beer-Lambert correction (Equation 3) to account for water absorption. For indoor cells, we used the same set of equations but replaced D with 0. The optimization process involved calculating efficiency, power output, and optimal bandgap by evaluating Equations 1 and 2, and maximizing the JV product in Equation 4 to obtain Jmax Vmax. This allowed us to determine the detailed-balance efficiency limit for given absorption spectra and specific values of Eg, D, and Tc. Through this approach, we identified optimal solar cell designs for both underwater and indoor environments. [2] [4]

Results

From 2m to 4m, red light (600-700 nm) diminishes significantly, leaving a blue-green dominated spectrum (450-600 nm) which is evident in figure 4. LED lighting's normalized irradiance (Figure 4, bottom) closely resembles these underwater spectral profiles, particularly in the blue-green range.

Figure 6 compares solar cell efficiency under AM 1.5G sunlight, underwater conditions, and indoor LED lighting. Figure 7's optimum bandgap vs. input power graph reveals a convergence between underwater and indoor optimal bandgaps. While underwater conditions vary with input power, indoor LED optimal bandgaps remain consistent across color temperatures and input powers, suggesting a single solar cell design could potentially serve both environments.

Figure 6: Efficiency Comparison of Solar Cells Under Depths and LEDs

Figure 7: Optimum Bandgap vs Power Input

Our analysis from Fig 6 and 7 shows that optimal band gaps for underwater solar cells range from 1.75 to 2.05 eV at depths of 2-4 meters, with efficiencies of 54-60% and power outputs of 8-21 mW/cm². For indoor LED lighting, optimal band gaps fall within a similar range of 1.75 to 1.9 eV, with efficiencies between 52-62% depending on input power.

Conclusion

Our research reveals a promising overlap in the optimal band gap ranges for underwater and indoor solar cells, centering around 1.75 to 1.9 eV. This convergence opens the door to developing solar cells capable of efficient operation in both underwater and indoor settings. Such dual-purpose cells could significantly advance IoT technologies, powering underwater sensors, smart building systems, and a wide range of devices that transition between these environments. The stability of optimal band gaps across various LED color temperatures and input powers further supports the feasibility of this approach.

Works Cited

Acknowledgement

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

This summer, a fleet of climate action clocks were created in collaboration with organizers of the NYC Climate Clock team. The action clocks, which address a need for eye-catching climate awareness, are a tool that allows climate organizers around the globe to communicate their message in a standardized format. The clocks were built with well-known, open-source hardware and software tools, including Arduino, Raspberry Pi, and Python. The fleet of clocks, mostly action clocks and DIY kits for high school and college students, succeed in their purpose of bringing climate awareness to the masses in a fun and educational manner. This summer, the clocks were presented at various local climate events, such as Extinction Rebellion's performance at Times Square–Enemy of the People–and Climate Emergency Day. The tools and techniques developed this summer will be used to develop a curriculum on climate and environmental justice for an outreach program in NYC.

Project Supervisor Ingrid Paredes

Research Areas Sustainability



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Spring 2027
NYU Tandon



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

Darryl Linardi, Mechanical Engineering, NYU Tandon School of Engineering

01 Abstract

This summer, a fleet of climate action clocks were created in collaboration with organizers of the NYC Climate Clock team. The action clocks, which address a need for eye-catching climate awareness, are a tool that allows climate organizers around the globe to communicate their message in a standardized format. The clocks were built with well-known, open-source hardware and software tools, including Arduino, Raspberry Pi, and Python. The fleet of clocks, mostly action clocks and DIY kits for high school and college students, succeed in their purpose of bringing climate awareness to the masses in a fun and educational manner. This summer, the clocks were presented at various local climate events, such as Extinction Rebellion's performance at Times Square–Enemy of the People–and Climate Emergency Day. The tools and techniques developed this summer will be used to develop a curriculum on climate and environmental justice for an outreach program in NYC.

02 Background

In the words of Climate Clock's two creators: the exact number does not matter, it is about the message being sent, that we are running out of time. The original handheld climate clock was a commission for Greta Thunberg's now well-known speech at the UN General Assembly. From there, the clock went on to become a permanent installation at Union Square, repurposing a prior art installation in true maker fashion. The clock's current timeline has been revised once, but otherwise has ticked down at the same rate since its inception. The orange/red numbers is the timeline representing the amount of time we have left before the Earth's average surface temperature reaches 1.5 degrees Celsius above pre-industrial levels. 1.5 C does not sound like a huge difference for a few generations of time, but the impacts it carries with it, such as extreme weather events and increased conflict are the focus of the movement.

05 Conclusion

In conclusion, the clock has made much apparent impact in the realm of activism and awareness from which it was created out of. But, as reflected through its programming this summer, it also has much untapped potential in the realm of academia; particularly in the field of secondary and higher education systems, where the action clocks are more likely to make a difference towards the world by communicating directly with the future generations of stewards for the world. The clocks, in both the technical engineering face and the climate awareness face, are looking to be integrated into NYU's learning environment in the near future, through a new VIP and possibly into a Tandon class.

03 Methodology

The materials for building a standard handheld action clock consist of 3 LED matrix display panels, a matrix display board, an RTC, a piezo buzzer, a power supply MOSFET, a potentiometer, a rotary encoder, a battery pack, a barrel jack plug, and various wires, contained in a wooden case with drawer handles on each end and a plexiglass lid screwed onto the back. After assembly, installation of software is either done through the command line or by drag-dropping files onto the matrix board's onboard storage; this however, is not necessary for the end-user to do.

04 Results

Over 30 clocks of varying size and function were built, of which multiple were brought to various Climate Clock-supported events such as the Enemy of the People event at Times Square's Red Steps on June 12th, during which Bill Murray, Kathryn Erbe, Taylor Schilling, Zach Grenier, Peter Francis James, Jay O' Sanders, Jumaane Williams, Peter Marks, Nate Smith, Bryan Doerries acted out roles from the classic play. The play touches upon power, money, politics, media, climate action, environmental justice, and public health, in a way relevant to today's society. Additionally, the annual Climate Emergency Day on July 22nd was a highlight of climate clock impact and impression in the realm of activism and awareness, where the creators and various activists spoke and gathered at the "Big Clock" at Union Square for the countdown for when the clock's day and time hits zero and drops by a year.

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Ramsauer Townsend Effect

The Ramsauer Townsend effect is a quantum mechanical phenomenon such that when electrons collide with inert gas atoms at certain energy, the atoms become essentially transparent to the electron. This typically occurs when the DeBroglie wavelength of the electron is on the same order as the size of the atom. The effect was first observed by Ramsauer and Townsend prior to the development of quantum mechanics theory. In this research, we use a thyratron tube with xenon gas to observe the effect. The thyratron consists of a cathode, anode and shield. The electrons, which are produced by a heater element, accelerate through low pressure xenon between the cathode and anode. Scattered electrons are more readily deflected to the shield. At the proper energy when the scattering is minimal due to the Ramsauer Townsend effect, more of the electrons reach the anode. We have observed the associated peak in the anode current. From this we have made measurements of the collision probability as a function of the cathode voltage. Preliminary observations also indicate evidence for a second minimum (at higher energy) in the effective scattering cross section

Project Supervisor David Mugglin

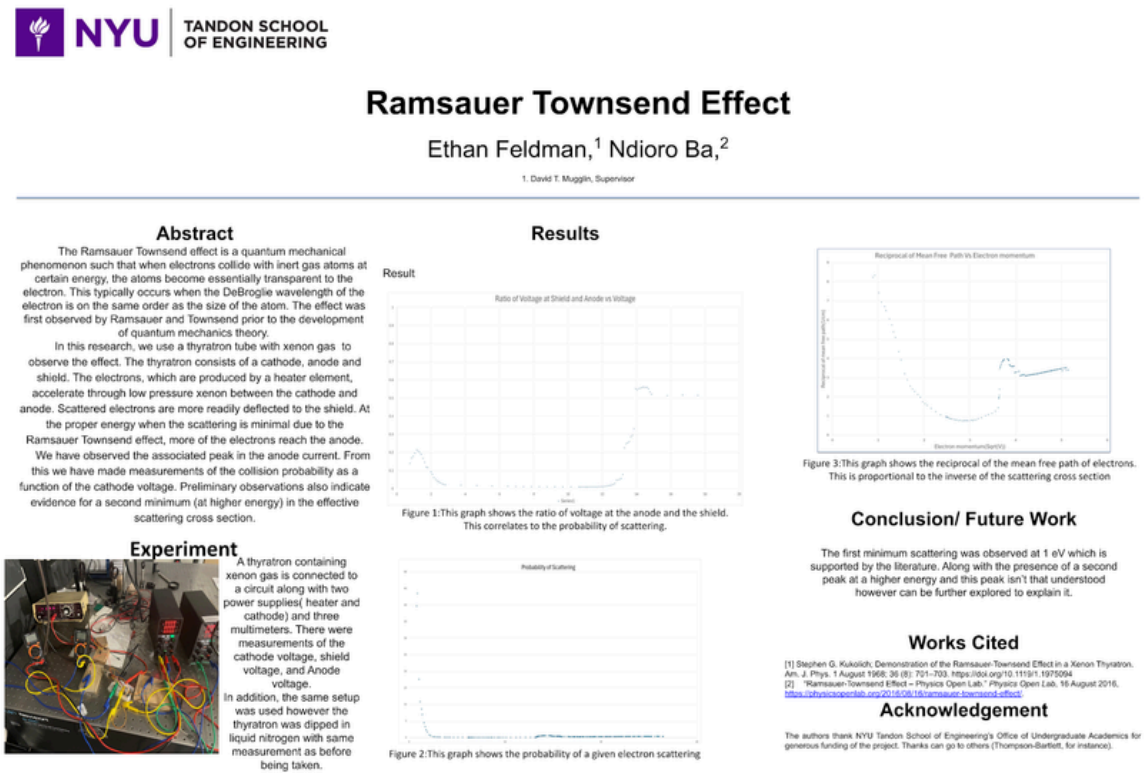
Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

Ramsauer Townsend Effect

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1. David T. Mugglin, Supervisor

Abstract

The Ramsauer Townsend effect is a quantum mechanical phenomenon such that when electrons collide with inert gas atoms at certain energy, the atoms become essentially transparent to the electron. This typically occurs when the DeBroglie wavelength of the electron is on the same order as the size of the atom. The effect was first observed by Ramsauer and Townsend prior to the development of quantum mechanics theory.
In this research, we use a thyratron tube with xenon gas to observe the effect. The thyratron consists of a cathode, anode and shield. The electrons, which are produced by a heater element, accelerate through low pressure xenon between the cathode and anode. Scattered electrons are more readily deflected to the shield. At the proper energy when the scattering is minimal due to the Ramsauer Townsend effect, more of the electrons reach the anode. We have observed the associated peak in the anode current. From this we have made measurements of the collision probability as a function of the cathode voltage. Preliminary observations also indicate evidence for a second minimum (at higher energy) in the effective scattering cross section.

Experiment

A thyratron containing xenon gas is connected to a circuit along with two power supplies(heater and cathode) and three multimeters. There were measurements of the cathode voltage, shield voltage, and Anode voltage.
In addition, the same setup was used however the thyratron was dipped in liquid nitrogen with same measurement as before being taken.

Results

Result

Figure 1:This graph shows the ratio of voltage at the anode and the shield. This correlates to the probability of scattering.

Figure 2:This graph shows the probability of a given electron scattering

Figure 3:This graph shows the reciprocal of the mean free path of electrons. This is proportional to the inverse of the scattering cross section

Conclusion/ Future Work

The first minimum scattering was observed at 1 eV which is supported by the literature. Along with the presence of a second peak at a higher energy and this peak isn't that understood however can be further explored to explain it.

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[2] "Ramsauer-Townsend Effect – Physics Open Lab." Physics Open Lab, 16 August 2016, https://physicsopenlab.org/2016/08/16/ramsauer-townsend-effect/

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks can go to others (Thompson-Bartlett, for instance).

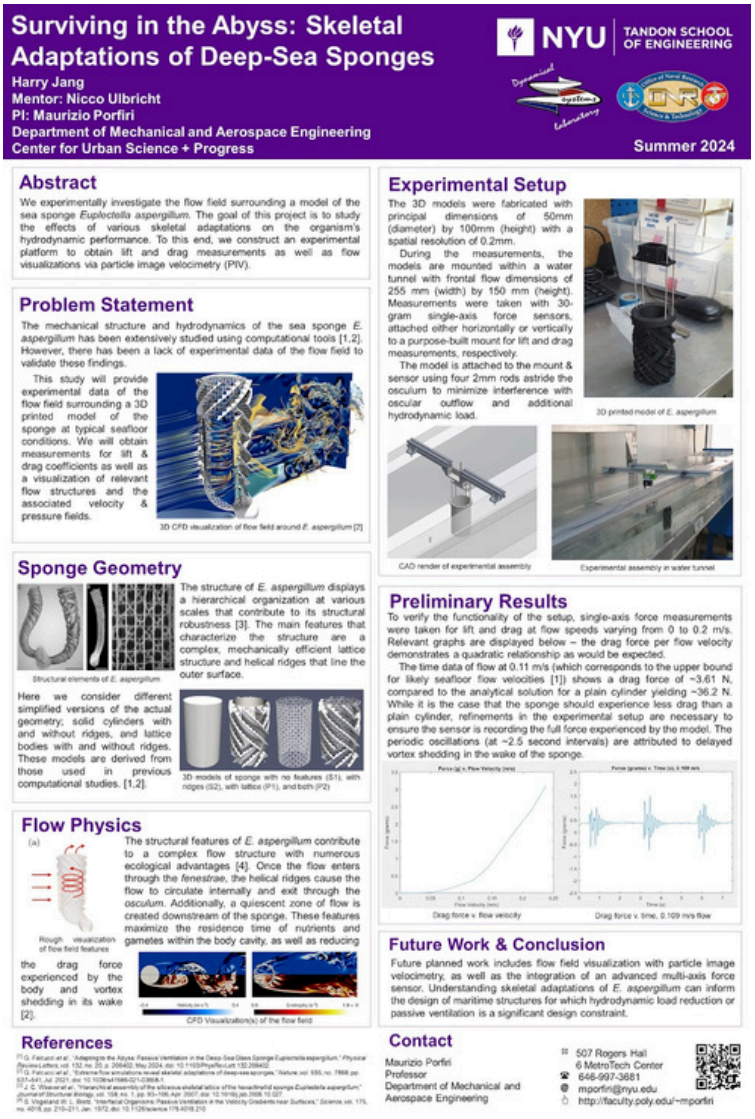
Surviving the Abyss: Skeletal Adaptations of Deep-Sea Sponges

The sea sponge Euplectella aspergillum, commonly known as the Venus' flower basket, showcases nature's remarkable ability to adapt to the harshest environments. The skeletal structure of these deep-sea dwellers is optimized to offer both structural rigidity and stress mitigation. This is achieved through its unique structural motifs, exemplified by its hollow lattice structure surrounded by outer helical ridges. Numerical flow simulations unveil the role of these structures in the optimization of the flow physics both within and outside the deep-sea sponge's body, resulting in direct benefits for feeding and reproduction. Specifically, the helical ridges and lattice structure are responsible for increasing the fluid residence time in the body cavity and reducing the drag force experienced by the body. Although numerical simulations provide valuable insight, there has not been a dedicated experimental investigation of the flow field of this system. Here, we design an experimental platform that allows us to study the hydrodynamic performance of the skeletal adaptations of Euplectella aspergillum. We performed experiments using simplified 3D-printed models of the deep-sea sponge inside a water channel, making measurements of lift and drag forces experienced by the body. Plans for follow-up development include the use of particle image velocimetry (PIV) to visualize flow patterns across different flow regimes, with which we will reconstruct the corresponding pressure fields and conduct calculations to verify the drag and lift coefficients. The study integrates biomimetics and experimental mechanics to develop a deeper understanding of the hydrodynamics of deep-sea sponges. These results will inform the design of buildings, bridges, marine vessels, and other systems that need to effectively withstand hydrodynamic forces or utilize them in passive ventilation.

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Research Staff Nicco Ulbricht



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Mapping Innovation in Construction

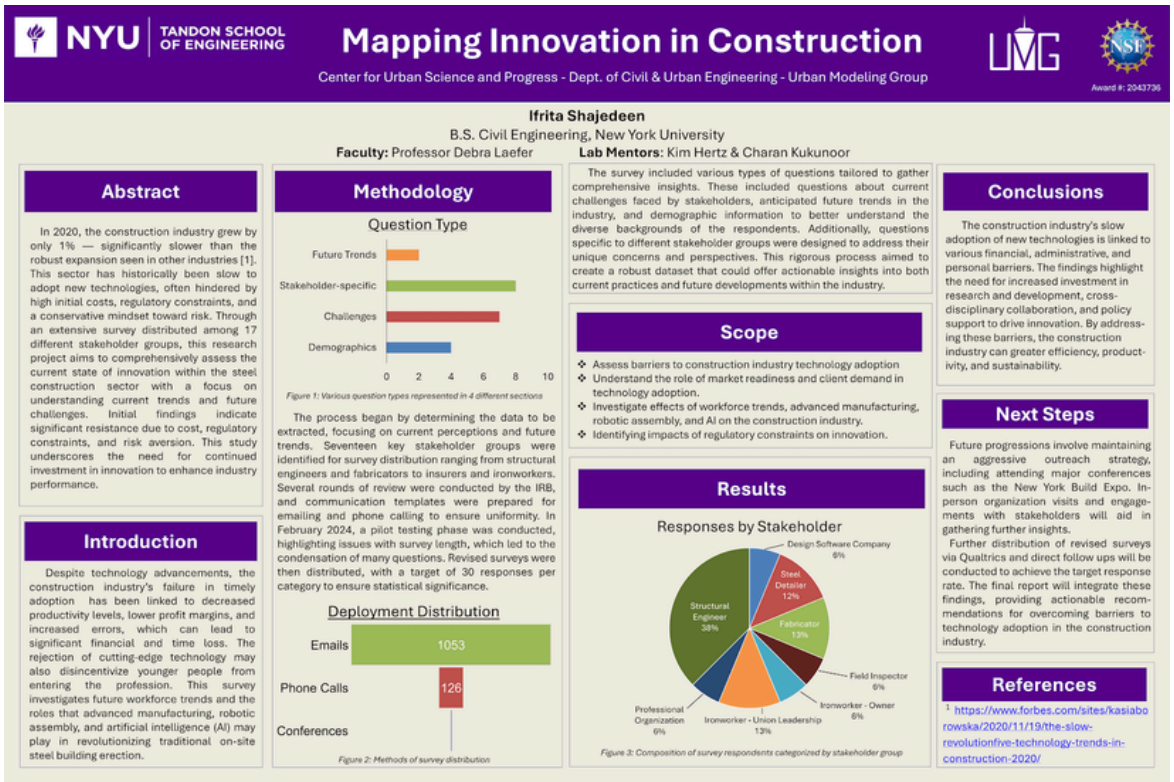
In 2020, the construction industry grew by only 1% — significantly slower than the robust expansion seen in other industries. The construction sector has historically been slow to adopt new technologies, often hindered by high initial costs, regulatory constraints, and a conservative mindset toward risk. Through an extensive survey distributed among 17 different stakeholder groups, this research project aims to comprehensively assess the current state of innovation within the steel construction sector and effectively categorize issues as financial, administrative, or personal. This survey investigates future workforce trends and the role of advanced manufacturing, robotic assembly, and artificial intelligence (AI) in revolutionizing traditional on-site steel building erection. The distribution methods included emails, phone calls, and in-person conference tabling. The findings highlight the critical need for continued investment in research and development, cross-disciplinary collaboration, and policy support to drive the steel construction industry toward greater efficiency, resilience, and environmental responsibility. This project underscores the transformative potential of innovation in enhancing the performance and sustainability of steel structures, paving the way for future advancements in civil engineering and construction.

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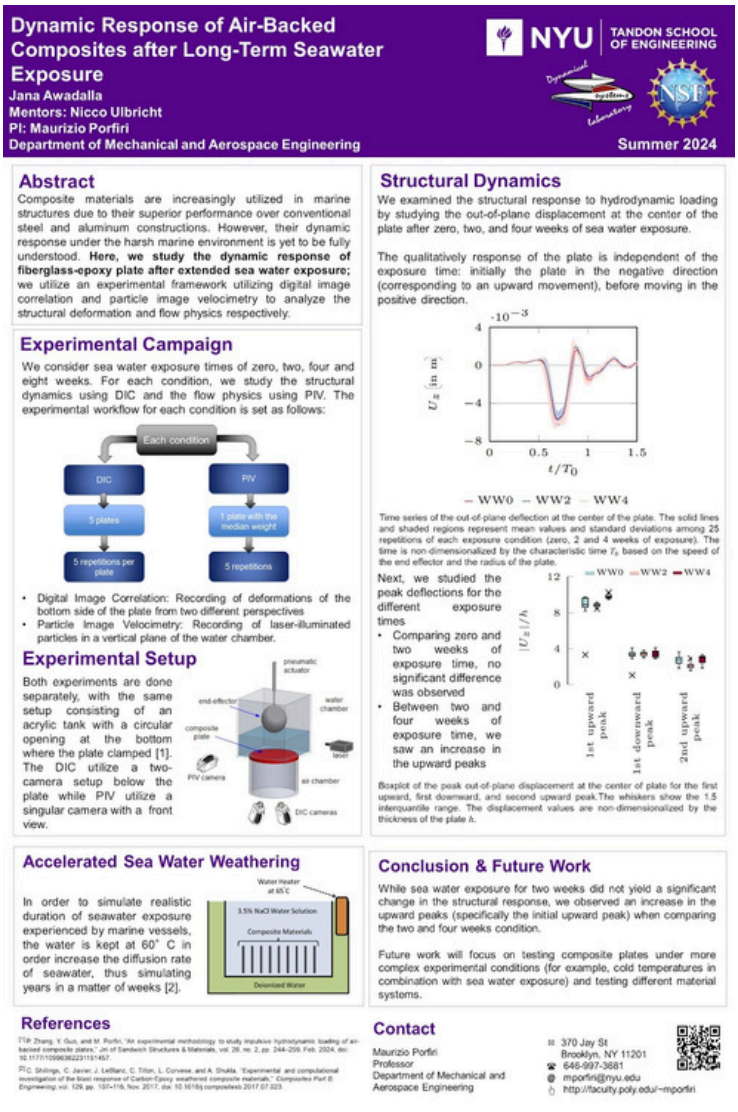
Dynamic Response of Air-Backed Composites after Long-Term Seawater Exposure

A greater deviation from traditional materials such as steel and aluminum to composite materials has been ongoing for over half a century in naval applications. This is due to their greater ability to withstand harsh marine environments; however, the impact of long-term seawater exposure on the dynamic response is yet to be completely understood. Here, we conducted a literature review on the effects of long-term seawater exposure on the mechanical properties of fiberglass-epoxy composite plates. While the majority of papers focused on change in the static properties (tensile strength, Young's modulus, fracture strength...etc.), only few explored the dynamic response. Furthermore, the papers that did explore dynamic responses, did that solely through structural deformations without assessing the corresponding fluid-structure interactions. In order to address this research gap, we studied both the structural deformations and fluid flow. We used three-dimensional digital correlation and particle image velocimetry on fiber-glass epoxy plates exposed to seawater for two, four, and eight weeks; each condition having 5 plates to test with multiple repetitions to ensure the statistical significance of the results. Both experiments utilized similar setups; a water-filled tank with a plate mounted to the bottom with an end effector that comes down to induce the hydrodynamic loading. The differences in the setups include positioning and number of cameras used, and PIV utilizes a laser while DIC does not. To simulate the chemical degradation of composite plates, we utilized an accelerated weathering facility. The plates are placed in a large tank filled with saltwater kept at 65°C instead of room temperature in order to increase the diffusion rate. After collecting the data and conducting the post-processing, we will be able to compare results for plates of different seawater exposure based on maximum deformation, young's modulus, damping properties, and deformation patterns.

Project Supervisor	Maurizio Porfiri
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Research Staff	Nicco Ulbricht



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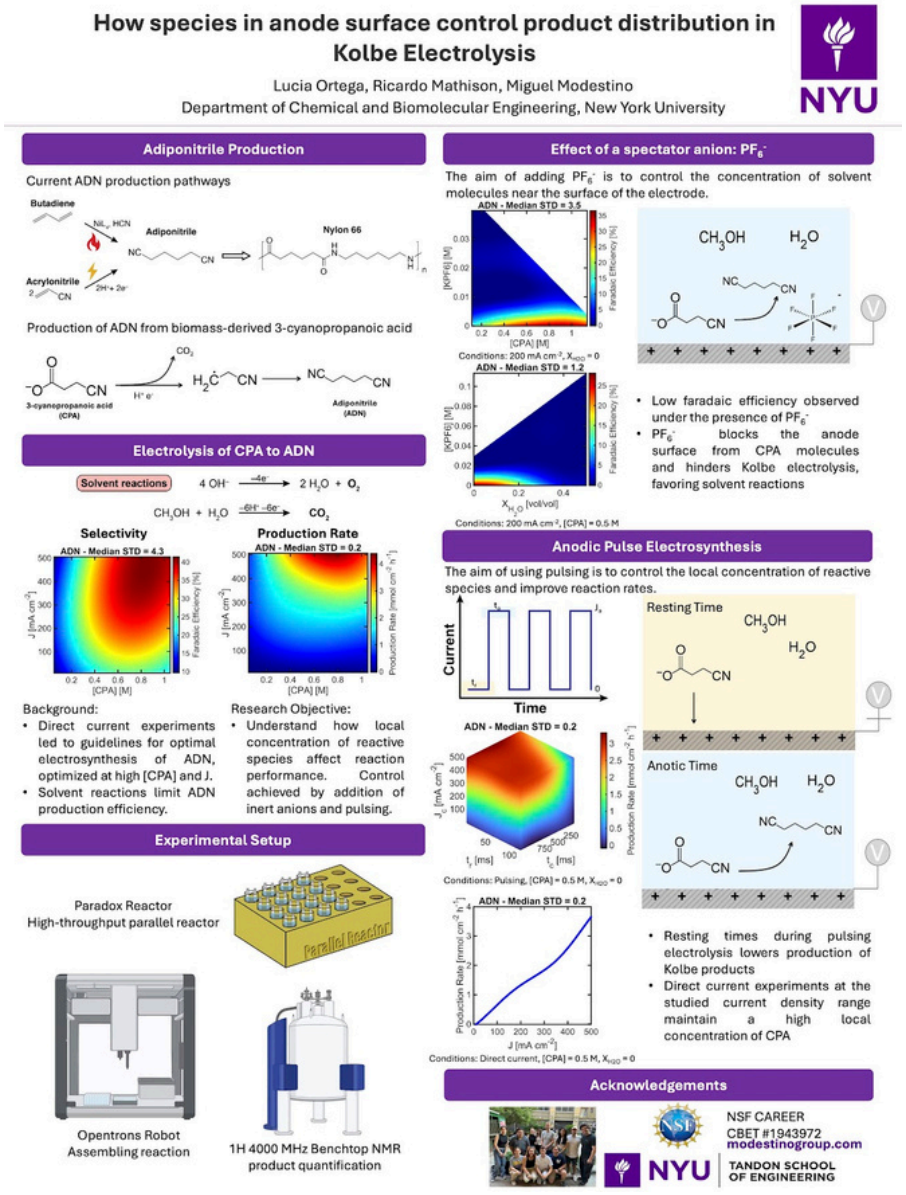
How Species in Anode Surface Control Product Distribution in Kolbe Electrolysis

The production of organic molecules is crucial in various industrial applications, and it heavily relies on fossil fuel exploitation. This dependency raises significant environmental concerns, including pollution, greenhouse gas emissions, and resource depletion. Organic electrosynthesis, uses electricity from renewable sources to drive chemical reactions. This approach offers a sustainable alternative for producing these essential molecules and minimizing environmental impact. Adiponitrile (ADN) is an organic compound crucial as a precursor in the production of Nylon 6,6 - a material widely used in industry. Currently, ADN production heavily depends on fossil fuels, contributing to significant environmental concerns. This reaction has relatively low eDicacy and production rates. The application of organic electrosynthesis to ADN production represents a key opportunity to address these issues. This study is focused on a more sustainable way to produce ADN from glutamic acid through the electrolysis of 3-cyanopropanoic acid (CPA), with the aim of decreasing solvent reactions and therefor improving and controlling the reaction selectivity and production rates of ADN. For this we took two approaches: adding PF6- to control the concentration of solvent molecules near the surface of the electrode. The second approach was applying anodic pulse electrosynthesis to control the local concentration of reactive species and improve reaction rates and efficiency.

Project Supervisor Miguel Modestino
Research Areas Sustainability
Research Staff Ricardo Mathison



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Developing Multiphysics Models for Comprehensive Simulation of Engineering Equipment

Thermofluids simulation plays a pivotal role in optimizing the design and operational efficiency of various engineering processes. This research leverages COMSOL Multiphysics to develop advanced simulation models that enhance our understanding of heat transfer, fluid dynamics, and their interactions in chemical engineering applications. Specifically, it involves the creation of comprehensive simulation models that accurately represent the complex interplay between different physical phenomena in stirred chemical reactors. NYU's high-performance computing (HPC) resources are utilized to handle the intense computational requirements of these simulations.

Project Supervisor Xin Wang

Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

Developing Multiphysics Models for Comprehensive Simulation of Engineering Equipment

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Abstract

The development of accurate Multiphysics models in software is crucial for advancing the capabilities of various engineering equipment. This research project focuses on developing a comprehensive simulation framework using COMSOL Multi-physics, targeting stirred chemical reactors as a primary application but extending its methodology to a wide range of engineering systems.

Methodology

The process begins with the creation of a dimensionally accurate domain model of the targeted equipment, capturing its geometry and initial phase distribution for any present multi-species fluids or solids. This model is then imported into COMSOL for final partitioning.

Setting up the simulations requires precise initial values, which are sourced from equipment manuals or laboratory measurements. When these values are unavailable or challenging to measure, educated estimates are used, with the understanding that the iterative nature of simulation will progressively correct any errors in the initial estimate.

The most challenging aspect of the simulation process is achieving proper setup and convergence. Convergence is attained when the simulation results stabilize and become accurate, indicating the model's validity.

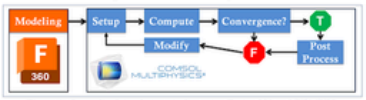


Figure 1: Generalized simulation pipeline using Fusion 360 and COMSOL.

As illustrated in (***Figure 1***), the simulation methodology is inherently iterative. If convergence is not achieved, it often indicates issues with the setup or insufficient boundary conditions. In such cases, the process loops back to the setup stage for adjustments, continuing this cycle until the solution converges.

Results

The simulation results in this research primarily serve a visual representational purpose rather than providing precise engineering values. This is due to the difficulty in obtaining real-world data from the reactor for direct comparisons. However, when such data becomes available, it can be used to validate the accuracy of the simulations for engineering applications.

One very fascinating results is from a large eddy simulation, displaying detailed turbulence structures (***Figure 2***).

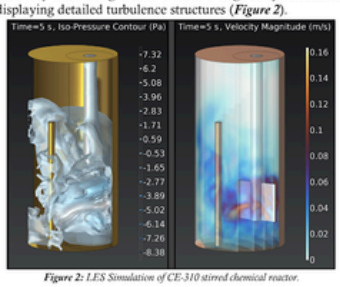


Figure 2: LES Simulation of CE-310 stirred chemical reactor.

To better visualize the fluid-air interface when a constantly revolving component is present, a simulation was completed using the Multiphase Flow, Level-Set interface in COMSOL (***Figure 3***).

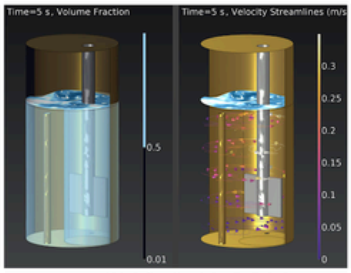


Figure 3: Level-Set interface with multiphase flow (water & air).

Moving Forward...

In the future, this research aims to refine the models further and incorporate additional physical phenomena occurring in real equipment. By enhancing the realism and accuracy of our simulations, we aspire to develop a robust methodology applicable across various scenarios.

Acknowledgement

The author thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Special thanks to research mentor Xin Wang for his invaluable guidance.

Least Squares Optimization of LEDs for Indoor Horticulture

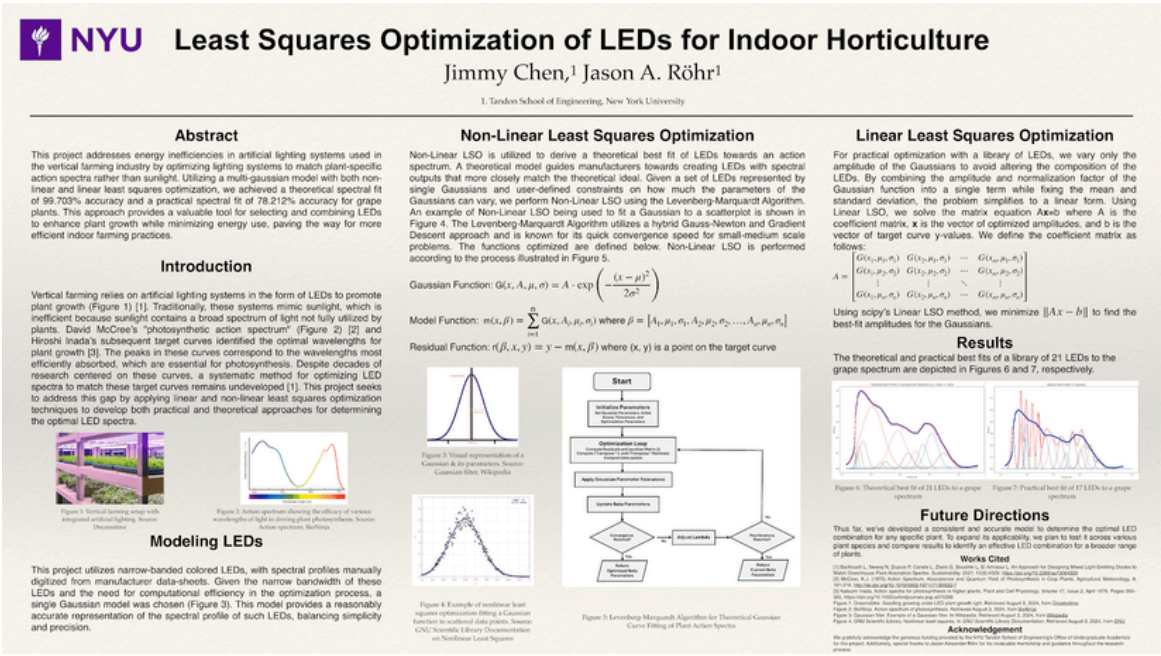
This project addresses the inefficiencies in artificial lighting systems used in the vertical farming industry, which are typically designed to replicate natural sunlight. The practice of designing artificial lighting to mimic sunlight results in significant energy waste, as the Sun emits a much broader range of wavelengths than plants can utilize efficiently. Our research aims to leverage computational models to identify optimal LED configurations that enhance plant growth while minimizing energy use corresponding to action spectra, i.e., spectra defining the amount and wavelength of light a specific plant needs to grow effectively, as measured by McCree and Inada. We propose both a practical and theoretical approach to identifying optimal LED configurations utilizing a multi-gaussian model with linear and non-linear least squares optimization, respectively. By utilizing a library of gaussians to approximate various color LEDs and applying user-defined constraints on gaussian parameter variations, our non-linear least squares optimization approach can determine the optimal LED combination to fit any action spectrum. With a library of 21 LEDs, we achieved a theoretical spectral fit of 99.703% accuracy to the action spectrum of a grape. This method models the ideal spectral distribution necessary for maximizing plant growth, tailored to specific LEDs and Gaussian parameter tolerances. Additionally, we applied linear least squares optimization to derive a practical LED configuration, achieving a realistic spectral fit of 78.212% accuracy. This approach not only emphasizes theoretical precision but also ensures practical applicability. The model provides a valuable tool into the selection and combination of LEDs, paving the way for more efficient and effective indoor vertical farming practices. In the future, we hope to identify both plant-specific and general-purpose LED combinations utilizing our current model.

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NYU Least Squares Optimization of LEDs for Indoor Horticulture

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1. Tandon School of Engineering, New York University

Abstract

This project addresses energy inefficiencies in artificial lighting systems used in the vertical farming industry by optimizing lighting systems to match plant-specific action spectra rather than sunlight. Utilizing a multi-gaussian model with both non-linear and linear least squares optimization, we achieved a theoretical spectral fit of 99.703% accuracy and a practical spectral fit of 78.212% accuracy for grape plants. This approach provides a valuable tool for selecting and combining LEDs to enhance plant growth while minimizing energy use, paving the way for more efficient indoor farming practices.

Introduction

Vertical farming relies on artificial lighting systems in the form of LEDs to promote plant growth (Figure 1) [1]. Traditionally, these systems mimic sunlight, which is inefficient because sunlight contains a broad spectrum of light not fully utilized by plants. David McCree's "photosynthetic action spectrum" (Figure 2) [2] and Hiroshi Inada's subsequent target curves identified the optimal wavelengths for plant growth [3]. The peaks in these curves correspond to the wavelengths most efficiently absorbed, which are essential for photosynthesis. Despite decades of research centered on these curves, a systematic method for optimizing LED spectra to match these target curves remains undeveloped [1]. This project seeks to address this gap by applying linear and non-linear least squares optimization techniques to develop both practical and theoretical approaches for determining the optimal LED spectra.

Modeling LEDs

This project utilizes narrow-banded colored LEDs, with spectral profiles manually digitized from manufacturer data-sheets. Given the narrow bandwidth of these LEDs and the need for computational efficiency in the optimization process, a single Gaussian model was chosen (Figure 3). This model provides a reasonably accurate representation of the spectral profile of such LEDs, balancing simplicity and precision.

Non-Linear Least Squares Optimization

Non-Linear LSO is utilized to derive a theoretical best fit of LEDs towards an action spectrum. A theoretical model guides manufacturers towards creating LEDs with spectral outputs that more closely match the theoretical ideal. Given a set of LEDs represented by single Gaussians and user-defined constraints on how much the parameters of the Gaussians can vary, we perform Non-Linear LSO using the Levenberg-Marquardt Algorithm. An example of Non-Linear LSO being used to fit a Gaussian to a scatterplot is shown in Figure 4. The Levenberg-Marquardt Algorithm utilizes a hybrid Gauss-Newton and Gradient Descent approach and is known for its quick convergence speed for small-medium scale problems. The functions optimized are defined below. Non-Linear LSO is performed according to the process illustrated in Figure 5.

Gaussian Function: $G(x, A, \mu, \sigma) = A \cdot \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$

Model Function: $m(x, \beta) = \sum_{i=1}^{n} G(x, A_i, \mu_i, \sigma_i)$ where $\beta = [A_1, \mu_1, \sigma_1, A_2, \mu_2, \sigma_2, \ldots, A_n, \mu_n, \sigma_n]$

Residual Function: $r(\beta, x, y) = y - m(x, \beta)$ where (x, y) is a point on the target curve

Linear Least Squares Optimization

For practical optimization with a library of LEDs, we vary only the amplitude of the Gaussians to avoid altering the composition of the LEDs. By combining the amplitude and normalization factor of the Gaussian function into a single term while fixing the mean and standard deviation, the problem simplifies to a linear form. Using Linear LSO, we solve the matrix equation $Ax=b$ where A is the coefficient matrix, **x** is the vector of optimized amplitudes, and b is the vector of target curve y-values. We define the coefficient matrix as follows:

$$A = \begin{bmatrix} G(x_1, \mu_1, \sigma_1) & G(x_1, \mu_2, \sigma_2) & \cdots & G(x_1, \mu_n, \sigma_n) \\ G(x_2, \mu_1, \sigma_1) & G(x_2, \mu_2, \sigma_2) & \cdots & G(x_2, \mu_n, \sigma_n) \\ \vdots & \vdots & \ddots & \vdots \\ G(x_n, \mu_1, \sigma_1) & G(x_n, \mu_2, \sigma_2) & \cdots & G(x_n, \mu_n, \sigma_n) \end{bmatrix}$$

Using scipy's Linear LSO method, we minimize $\|Ax - b\|$ to find the best-fit amplitudes for the Gaussians.

Results

The theoretical and practical best fits of a library of 21 LEDs to the grape spectrum are depicted in Figures 6 and 7, respectively.

Future Directions

Thus far, we've developed a consistent and accurate model to determine the optimal LED combination for any specific plant. To expand its applicability, we plan to test it across various plant species and compare results to identify an effective LED combination for a broader range of plants.

Works Cited

Acknowledgement

Assessing the Feasibility of Deploying Solar-powered Underwater Devices in Waters Surrounding NYC

Solar energy collection in aquatic environments is promising for the deployment of solar-powered underwater sensors and communication devices, which could revolutionize environmental and oceanographic monitoring. However, identifying optimal solar technologies for these applications is challenging because of the time and material costs of field deployments. This research aims to estimate the feasibility of underwater solar-powered devices using computational models based on waters' absorbance data. Water samples were firstly collected from various locations around New York City, including the East River, Bowery Bay, Flushing Bay, Little Neck Bay, Harlem River, Long Island Sound, Hudson River, and Jamaica Bay. These water samples were analyzed using a Cary 60 UV-Vis spectrophotometer to measure absorbance from wavelength of 300 nm to 800 nm. The absorbance data was processed using Python-based code to calculate absorption coefficients, which were then plotted to visualize the characteristics of each water source. By comparing the absorption coefficient of different water sources, whether the sunlight would be sufficient to power basic electronics were examined. The data were inserted into computational solar cell models. The result was that the maximum coefficient at 0.4m under water is 46%, and the maximum bandgap is 1.65eV. It is feasible to utilize underwater devices to generate power around NYC.

Project Supervisor Jason Röhr

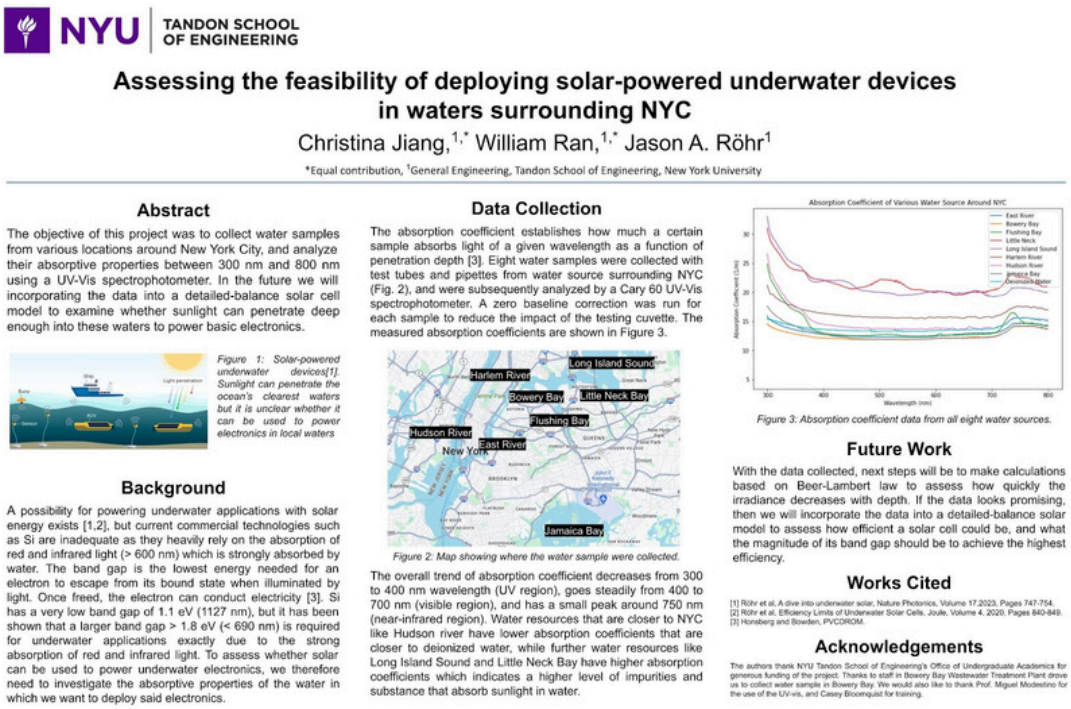
Research Areas Sustainability



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NYU TANDON SCHOOL OF ENGINEERING

Assessing the feasibility of deploying solar-powered underwater devices in waters surrounding NYC

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Abstract

The objective of this project was to collect water samples from various locations around New York City, and analyze their absorptive properties between 300 nm and 800 nm using a UV-Vis spectrophotometer. In the future we will incorporating the data into a detailed-balance solar cell model to examine whether sunlight can penetrate deep enough into these waters to power basic electronics.

Figure 1: Solar-powered underwater devices[1]. Sunlight can penetrate the ocean's clearest waters but it is unclear whether it can be used to power electronics in local waters

Background

A possibility for powering underwater applications with solar energy exists [1,2], but current commercial technologies such as Si are inadequate as they heavily rely on the absorption of red and infrared light (> 600 nm) which is strongly absorbed by water. The band gap is the lowest energy needed for an electron to escape from its bound state when illuminated by light. Once freed, the electron can conduct electricity [3]. Si has a very low band gap of 1.1 eV (1127 nm), but it has been shown that a larger band gap > 1.8 eV (< 690 nm) is required for underwater applications exactly due to the strong absorption of red and infrared light. To assess whether solar can be used to power underwater electronics, we therefore need to investigate the absorptive properties of the water in which we want to deploy said electronics.

Data Collection

The absorption coefficient establishes how much a certain sample absorbs light of a given wavelength as a function of penetration depth [3]. Eight water samples were collected with test tubes and pipettes from water source surrounding NYC (Fig. 2), and were subsequently analyzed by a Cary 60 UV-Vis spectrophotometer. A zero baseline correction was run for each sample to reduce the impact of the testing cuvette. The measured absorption coefficients are shown in Figure 3.

Figure 2: Map showing where the water sample were collected.

The overall trend of absorption coefficient decreases from 300 to 400 nm wavelength (UV region), goes steadily from 400 to 700 nm (visible region), and has a small peak around 750 nm (near-infrared region). Water resources that are closer to NYC like Hudson river have lower absorption coefficients that are closer to deionized water, while further water resources like Long Island Sound and Little Neck Bay have higher absorption coefficients which indicates a higher level of impurities and substance that absorb sunlight in water.

Figure 3: Absorption coefficient data from all eight water sources.

Future Work

With the data collected, next steps will be to make calculations based on Beer-Lambert law to assess how quickly the irradiance decreases with depth. If the data looks promising, then we will incorporate the data into a detailed-balance solar model to assess how efficient a solar cell could be, and what the magnitude of its band gap should be to achieve the highest efficiency.

Works Cited

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[2] Röhr et al. Efficiency Limits of Underwater Solar Cells. Joule, Volume 4, 2020. Pages 840-849.
[3] Honsberg and Bowden, PVCDROM.

Acknowledgements

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks to staff in Bowery Bay Wastewater Treatment Plant drove us to collect water sample in Bowery Bay. We would also like to thank Prof. Miguel Modestino for the use of the UV-vis, and Casey Bloomquist for training.

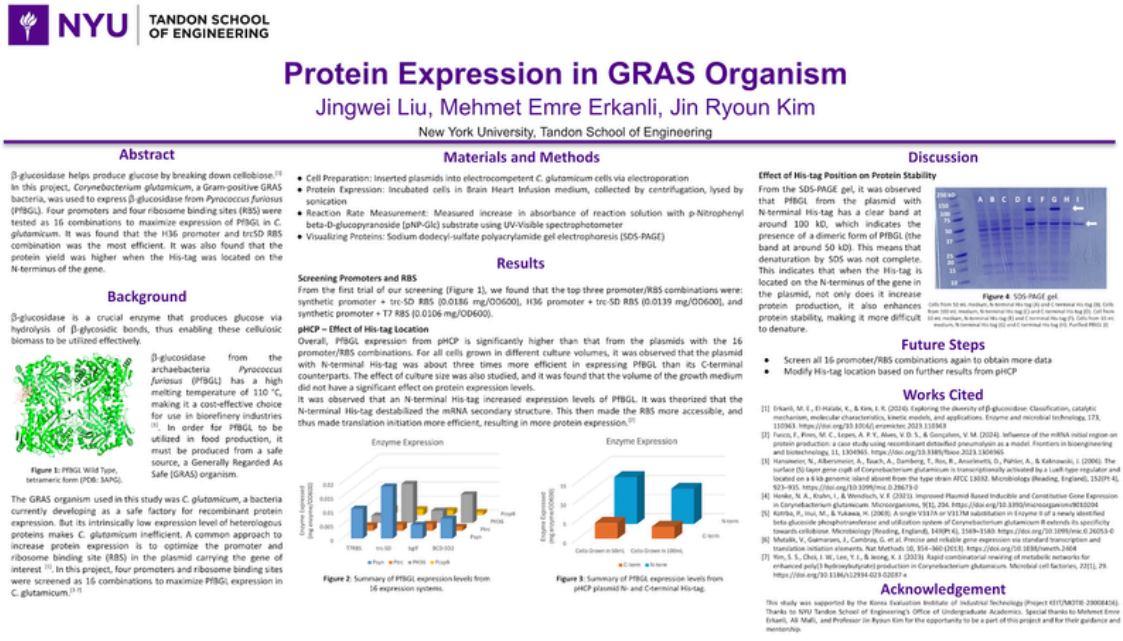
Protein Expression in GRAS Organism

Biorefinery technologies are essential in producing high-value chemicals from biomass. β-glucosidase is a crucial enzyme that breaks down aryl-glycosides and cello-oligosaccharides into glucose molecules. Because β-glucosidase is useful in food production, it should be expressed in generally regarded as safe (GRAS) organisms approved for production of food-grade proteins. In this project, Corynebacterium glutamicum, a Gram-positive GRAS bacteria, was used to express a β-glucosidase variant from Pyrococcus furiosus (PfBGL). Previously, inducible plasmid pEC-XK99E containing the lac operon was tested in C. glutamicum, but protein expression was not detected. Here, a non-inducible plasmid was used. Four promoters and four ribosome binding sites (RBS) were tested as 16 combinations to maximize expression of PfBGL in C. glutamicum. For each combination, C. glutamicum containing the corresponding plasmid was grown in Brain Heart Infusion medium, collected by centrifugation, and lysed by sonication. Cell lysate was isolated and enzyme activity was measured using an ultraviolet-visible (UV-Vis) spectrophotometer. Enzyme yield was calculated using the rate of change in absorbance and the PfBGL extinction coefficient. It was found that the synthetic promoter and T7 RBS combination produced the most PfBGL. The effect of His-tag location on protein expression was also investigated using another plasmid backbone, pHCP. Overall, the plasmid with N-terminal His-tag produced higher levels of PfBGL than did its C-terminal counterpart. It was observed that sonication conditions impacted protein yield. To optimize sonication conditions, five rounds of sonication were performed on the same cell sample, activity was measured after each round. It was found that increasing amplitude of sonication released more enzymes, resulting in higher measured enzyme expression. For further research, the 16 plasmids will be tested again in C. glutamicum using optimized sonication conditions. The plasmid with the best promoter-RBS combination will then be modified by changing the His-tag location based on further results from pHCP.

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Protein Expression in GRAS Organism

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Abstract

β-glucosidase helps produce glucose by breaking down cellobiose. In this project, Corynebacterium glutamicum, a Gram-positive GRAS bacteria, was used to express β-glucosidase from Pyrococcus furiosus (PfBGL). Four promoters and four ribosome binding sites (RBS) were tested as 16 combinations to maximize expression of PfBGL in C. glutamicum. It was found that the H36 promoter and trcSD RBS combination was the most efficient. It was also found that the protein yield was higher when the His-tag was located on the N-terminus of the gene.

Background

β-glucosidase is a crucial enzyme that produces glucose via hydrolysis of β-glycosidic bonds, thus enabling these cellulosic biomass to be utilized effectively.

β-glucosidase from the archaebacteria Pyrococcus furiosus (PfBGL) has a high melting temperature of 110 °C, making it a cost-effective choice for use in biorefinery industries. In order for PfBGL to be utilized in food production, it must be produced from a safe source, a Generally Regarded As Safe (GRAS) organism.

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

The GRAS organism used in this study was C. glutamicum, a bacteria currently developing as a safe factory for recombinant protein expression. But its intrinsically low expression level of heterologous proteins makes C. glutamicum inefficient. A common approach to increase protein expression is to optimize the promoter and ribosome binding site (RBS) in the plasmid carrying the gene of interest. In this project, four promoters and ribosome binding sites were screened as 16 combinations to maximize PfBGL expression in C. glutamicum.

Materials and Methods

- Cell Preparation: Inserted plasmids into electrocompetent C. glutamicum cells via electroporation
- Protein Expression: Incubated cells in Brain Heart Infusion medium, collected by centrifugation, lysed by sonication
- Reaction Rate Measurement: Measured increase in absorbance of reaction solution with p-Nitrophenyl beta-D-glucopyranoside (pNP-Glc) substrate using UV-Visible spectrophotometer
- Visualizing Proteins: Sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE)

Results

Screening Promoters and RBS

From the first trial of our screening (Figure 1), we found that the top three promoter/RBS combinations were: synthetic promoter + trc-SD RBS (0.0186 mg/OD600), H36 promoter + trc-SD RBS (0.0139 mg/OD600), and synthetic promoter + T7 RBS (0.0106 mg/OD600).

pHCP – Effect of His-tag Location

Overall, PfBGL expression from pHCP is significantly higher than that from the plasmids with the 16 promoter/RBS combinations. For all cells grown in different culture volumes, it was observed that the plasmid with N-terminal His-tag was about three times more efficient in expressing PfBGL than its C-terminal counterparts. The effect of culture size was also studied, and it was found that the volume of the growth medium did not have a significant effect on protein expression levels.

It was observed that an N-terminal His-tag increased expression levels of PfBGL. It was theorized that the N-terminal His-tag destabilized the mRNA secondary structure. This then made the RBS more accessible, and thus made translation initiation more efficient, resulting in more protein expression.

Figure 2: Summary of PfBGL expression levels from 16 expression systems.

Figure 3: Summary of PfBGL expression levels from pHCP plasmid N- and C-terminal His-tag.

Discussion

Effect of His-tag Position on Protein Stability

From the SDS-PAGE gel, it was observed that PfBGL from the plasmid with N-terminal His-tag has a clear band at around 100 kD, which indicates the presence of a dimeric form of PfBGL (the band at around 50 kD). This means that denaturation by SDS was not complete. This indicates that when the His-tag is located on the N-terminus of the gene in the plasmid, not only does it increase protein production, it also enhances protein stability, making it more difficult to denature.

Figure 4: SDS-PAGE gel.

Future Steps

- Screen all 16 promoter/RBS combinations again to obtain more data
- Modify His-tag location based on further results from pHCP

Works Cited

Acknowledgement

Innovation in Steel Construction: Technology Adoption

Roughly 98% of structural steel in the United States is recycled into new steel products. Although recycling is not as environmentally intense, there is still an economic footprint that needs to be addressed. The problem with the current model of steel recycling is that there are many key players within the industry, and since steel is constantly being transported between them, it is difficult to properly quantify the costs that they incur. By georeferencing major stakeholders (i.e. fabricators, manufacturers, mines, scrapyards, etc.) through ArcGIS, a mapping software, the research aims to visually identify distance trends within the industry. Through these trends, the goal is to create an alternative system that attempts to quantify these unidentified costs and reduce the movement of steel between many stakeholders. This comprehensive approach not only seeks to improve industry practices but also aims to significantly reduce energy consumption and environmental impact in the construction steel sector.

Project Supervisor Debra Laefer

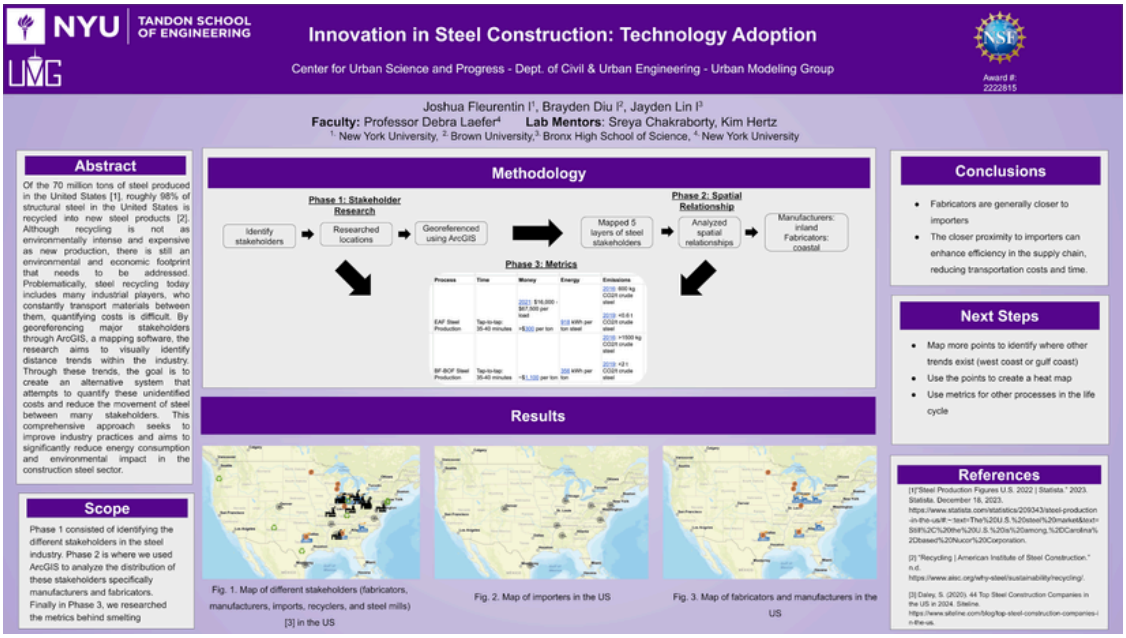
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Collidal Quantum Dots: Exploring the Properties of a New Peroskite Nanomaterial for Infrared Detection

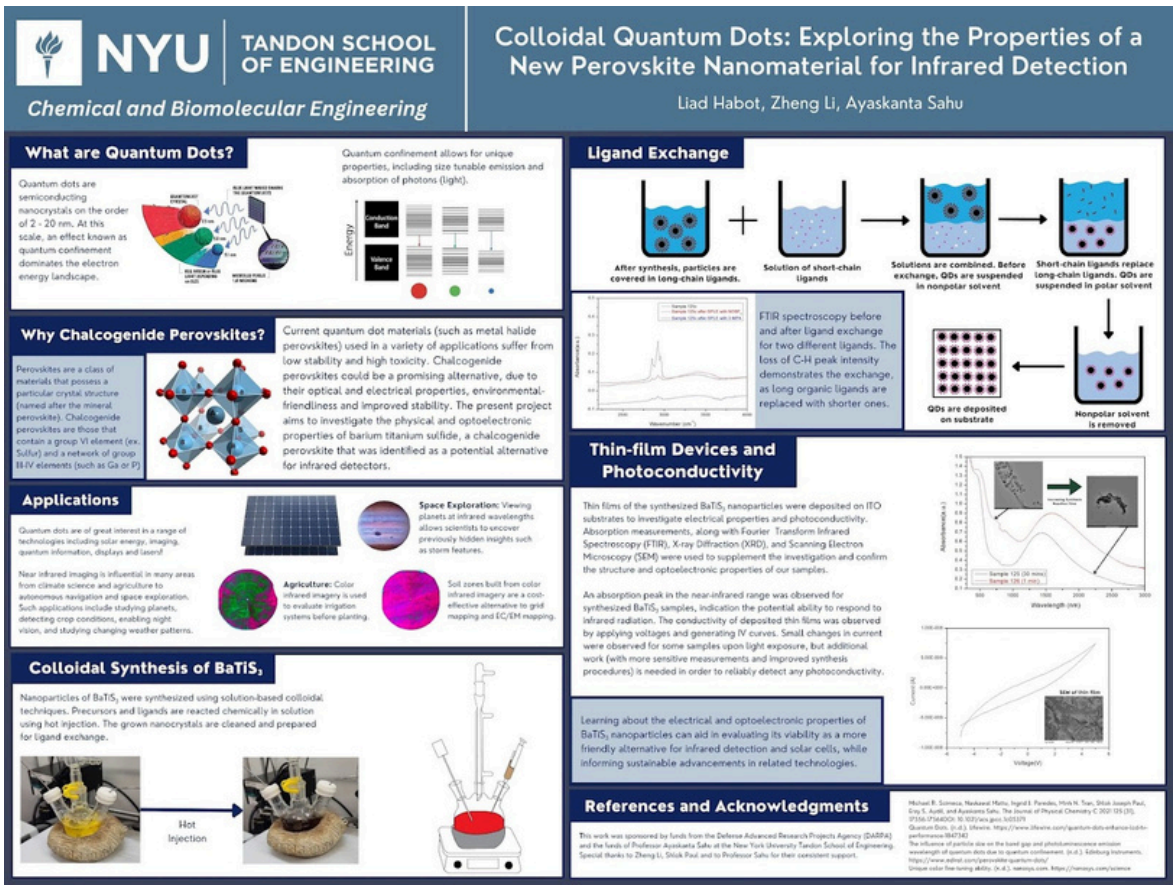
Quantum-confined semiconductor nanomaterials (quantum dots) exhibit unique and tunable physical properties. As such, quantum dots have recently risen to be of great interest in a range of technologies including solar energy capture, imaging, sensors, electronics, quantum information, displays, and lasers. This is due to the way that quantum dots interact with light and transport charge carriers, allowing for strong light absorption and bright narrowband emission across visible and infrared wavelengths. Infrared detection, particularly, is influential in many areas from climate research and agriculture to autonomous navigation and space exploration. Unfortunately, many materials currently used for quantum dots rely on heavy metals that pose dangers to human health and environmental sustainability, due to their toxicity. Chalcogenide perovskites are considered a promising alternative due to their optical and electrical properties, environmental-friendliness, as well as their improved thermal and aqueous stability. A better understanding of alternative materials and their properties would advance their usability in optoelectronic devices.

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Moving Towards a Mechanistic Understanding of Plasma Pesticide Degregation

Pesticides play a crucial role in food supply; however, as toxic chemicals designed to kill target species, their intensive use can be harmful to non-target organisms in the environment and potentially hazardous to humans. Consequently, the treatment and degradation of pesticides are critical considerations. An emerging engineering method using non-thermal plasma offers a unique insight into pesticide degradation due to its ability to produce complex reactions, involving high-energy electrons and energy transfer. However, there is a lack of understanding of the mechanisms by which plasmas degrade pesticides and how the degradation changes with plasma parameters, such as polarity and current. In this study, we develop a mechanistic model for pesticide degradation by plasma-generated reactive species. Probe molecules were used to determine the steady-state concentrations of various reactive species, including singlet oxygen (using 2,4,6-trimethylphenol), triplet excited states (using furfuryl alcohol), and hydroxyl radicals (using benzoic acid). The model reveals the relative contribution of these species towards the degradation of various pesticides. Additionally, our findings show that positive polarity plasma degraded pesticides approximately twice as effectively as negative polarity, and that plasma current significantly impacts degradation rates. While our simplified model does not predict total degradation due to other contributions in the complex plasma system, it provides a foundation for understanding plasma-induced pesticide degradation and offers design guidelines for plasma pesticide treatment systems.

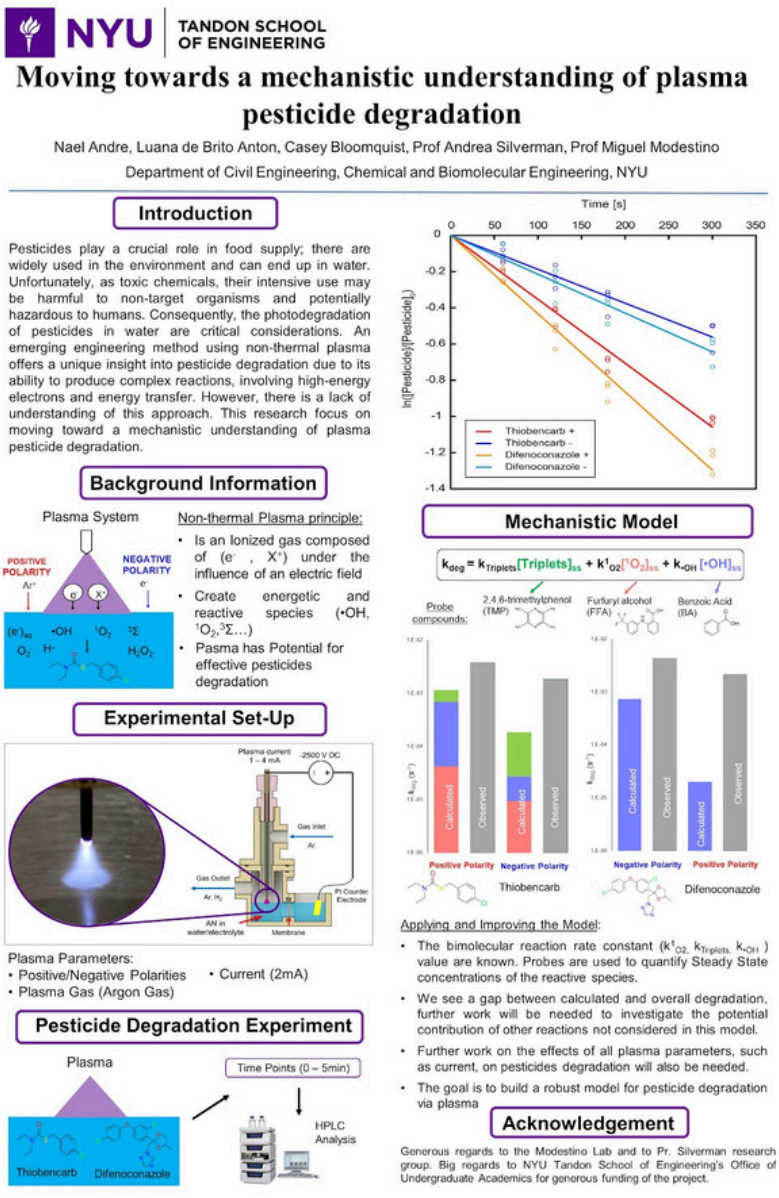
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Flash Joule Heating Nanocatalysts

Human beings depend on energy for survival, making the development of energy sources crucial for humanity. In addition to traditional sources, the advancement of clean energy is essential. Hydrogen energy, known for its environmental friendliness, enables zero emissions and pollution-free energy production, positioning it as a key new energy source in contemporary society. While hydrogen can be produced through electrolysis, the process is slow and requires a catalyst for acceleration. Platinum (Pt) is the most effective catalyst, but its high cost necessitates the search for more economical alternatives. Trimolybdenum phosphide (Mo3P) has emerged as a promising catalyst for the hydrogen evolution reaction (HER), demonstrating superior intrinsic potential. To synthesize this catalyst, we utilized flash joule heating (FJH), a method capable of rapidly producing desired amorphous nanomaterials within seconds, thereby enhancing catalytic performance. The synthesized Mo3P nanomaterial exhibits outstanding catalytic efficiency in HER, establishing it as a potential catalyst for future applications.

Project Supervisor André D. Taylor

Research Areas Sustainability



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Flash Joule Heating Nanocatalysts

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Abstract

Flash Joule Heating (FJH) enables rapid synthesis of compounds, producing amorphous materials within seconds. These compounds often possess high surface activity, making them effective catalysts. In electrochemical experiments, they demonstrate superior performance. In our study, we synthesized a Mo-P nanocompound using FJH, showcasing exceptional catalytic efficiency in the Hydrogen Evolution Reaction (HER), positioning it as a promising catalyst for future applications.

Background on the Project

In addition to traditional sources, the advancement of clean energy is essential.[1] Hydrogen energy, known for its environmental friendliness, enables zero emissions and pollution-free energy production, positioning it as a key new energy source in contemporary society. While hydrogen can be produced through electrolysis, the process is slow and requires a catalyst for acceleration. Platinum (Pt) is the most effective catalyst, but its high cost necessitates the search for more economical alternatives.[2] Trimolybdenum phosphide (Mo_3P) has emerged as a promising catalyst for the hydrogen evolution reaction (HER), demonstrating superior intrinsic potential.[3] To synthesize this catalyst, we utilized flash joule heating (FJH), a method capable of rapidly producing desired amorphous nanomaterials within seconds, thereby enhancing catalytic performance. These catalysts are now heavily utilized for hydrogen production.

Methodology

Total 36 μl of 0.05 M Ammonium Molybdate (para) tetrahydrate ($(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$), 0.05 M Phosphomolybdic acid hydrate ($H_3PMo_{12}O_{40}$), and 0.1M Ammonium Phosphate monobasic ($NH_4H_2PO_4$) were added to a carbon fiber paper as the ratio 2:2:5. The sample was placed inside a glove box for flash joule heating at 1404K for 2.5 seconds. Electrochemical experiments were conducted in a cell containing 0.5M H_2SO_4 electrolyte, with a $Hg/HgSO_4$ reference electrode, platinum counter electrode, and nitrogen gas atmosphere.

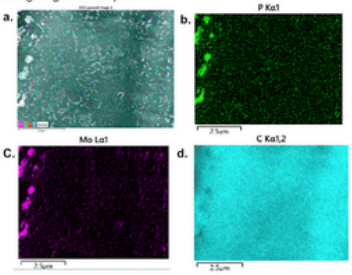
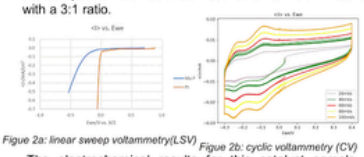


Figure 1: SEM and EDX of Mo-P nanocompound, a: overall particle distribution, b: phosphorus particle distribution, c: molybdenum particle distribution, d: carbon particle distribution

Results

The catalyst sample was synthesized successfully, demonstrating a well-distributed nanostructure as depicted in Figure 1. The molybdenum was found to be closely associated with phosphorus, distinct from the carbon background. The atomic ratio of Mo to P was approximately 3:1; however, XRD analysis indicated that the compound was not Mo3P but rather a Mo-P mixture with a 3:1 ratio.



Figue 2a: linear sweep voltammetry(LSV) *Figue 2b: cyclic voltammetry (CV)*

The electrochemical results for this catalyst sample were promising. Figure 2a shows that the Mo-P line approached zero, indicating excellent catalytic efficiency comparable to platinum. Moreover, figure 2b has clear peaks of hydrogen adsorption and hydrogen desorption at each scan rate.

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[4] Full citation here

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks can go to others (Thompson-Bartlett, for instance).

Impacts of Temporal Matching for Clean Electricity Procurement for Economy-wide Decarbonation

Recently, federal and state governments have been pushing for private and public businesses to have a deeper involvement in a de-carbonized future in the USA through government subsidies and financial incentive programs. In turn, businesses have been investing into teams of researchers to develop hourly and annual procurement methods to match their carbon consumption. The current process of certification of renewable energy purchases in the United States are Renewable Energy Certificates (RECs) which can be claimed by the owner when the certificate is retired.

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Impacts of Temporal Matching for Clean Electricity Procurement for Economy-wide Decarbonization

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Abstract

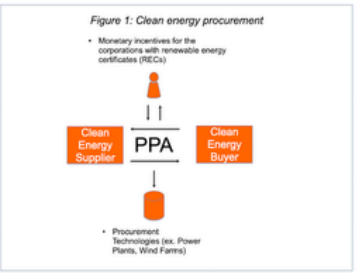
The transition to a decarbonized economy necessitates innovative strategies for clean electricity procurement, especially in light of increasing governmental incentives. This research project investigates the impacts of temporal matching approaches—specifically, annual and hourly matching—on cost-effectiveness and grid decarbonization. Using the DOLPHYN model and focusing on the Texas grid projected for 2040, this study explores the interplay between temporal matching requirements and existing grid decarbonization policies such as Renewable Portfolio Standards (RPS) and Clean Energy Standards (CES)

Background on the Project

Recently, federal and state governments have been pushing for private and public businesses to have a deeper involvement in a de-carbonized future in the USA through government subsidies and financial incentive programs. In turn, businesses have been investing into teams of researchers to develop hourly and annual procurement methods to match their carbon consumption. The current process of certification of renewable energy purchases in the United States are Renewable Energy Certificates (RECs) which can be claimed by the owner when the certificate is retired.

Temporal matching is the idea that we match energy procurement based on time-matching requirements, in this study we studied annual vs. hourly time matching requirements. For the setup of the project, we used the DOLPHYN model and the Texas grid for 2040 with some spatial resolution (6-9 zone).

Figure 1: Clean energy procurement

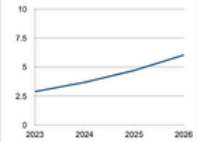


Methodology

In the process of researching the difference of annual and hourly renewable time matching requirements we implemented the GenX, a subsidiary of the overarching DOLPHYN energy model framework.

We tested four different cases, with hourly time matching for H2 with subsidy, hourly matching for H2 with subsidy with hourly matching for data center loads, hourly matching for H2, data centers, and renewable portfolio standard for other loads representing voluntary/mandated procurement, and renewable portfolio standards for all loads

Figure 2: Time Series Representation of the REC Market (in Billion $)



As we complete the results of the research study, we are lead to continue researching some open questions in electricity procurements for a decarbonized future, such as how we can understand the REC market impact from decarbonizing the electricity grid, as well as understanding how the implications of a unified market for RECs vs. bifurcated market for different types of REC products.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project and Professor Dharik Mallapragada SET Group.

Electrosynthesis: Conductivity and Structural Analysis of Nafion-177 Membranes Saturated in Binary Solutions

Electrosynthesis stands at the forefront of sustainable chemical production, significantly reducing environmental impact, eliminating hazardous reagents, and minimizing waste. Notably, in the industrial production of adiponitrile, electrosynthesis has demonstrated a remarkable 37% reduction in energy consumption. This study explores the application of electrosynthesis in the production of adiponitrile, the most significant industrial electrosynthetic organic chemical. The purpose of this research is to investigate the critical role of ionomers in electrosynthesis, focusing on optimizing ion transport and membrane technologies to enhance efficiency across various electrochemical processes. Methods include the use of Fourier Transform Infrared Spectroscopy on membranes saturated with various solutions to analyze structural properties and interactions. Additionally, the conductivity of these membranes was measured to assess how different chemical components in adiponitrile production influence the structure-transport properties of Nafion. These methods aim to identify the most efficient and sustainable configurations. Results indicate that the strategic use of ionomers can significantly enhance ion transport and membrane stability, leading to improved reaction efficiencies and further reductions in energy consumption. The findings of this study are expected to translate into practical enhancements, paving the way for more efficient and sustainable chemical production systems, thereby advancing the field of sustainable chemistry.

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Electrosynthesis: Conductivity and Structural Analysis of Nafion-117 Membranes Saturated in Binary Solutions

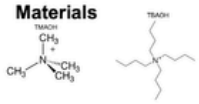
Scarly Benitez, Mihyun Kim, Miguel Modestino, Department of Chemical and Biomolecular Engineering, New York University

Introduction

- Chemical industry accounts for 18% of global industrial CO_2 emission [1]
- Largest electrochemical production: Adiponitrile (precursor to Nylon 6,6) [2]
- Optimization of ion transport and membrane technologies is needed to enhance efficiency across electrochemical processes.

Materials

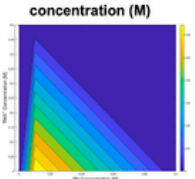
- TMAOH
- TBAOH
- PN
- Nafion-117



Methods

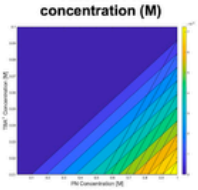
- Prepared binary solutions using Propionitrile and Tetrabutylammonium (TBA) or Tetramethylammonium (TMA).
- Saturated Nafion-117 membranes in the prepared binary solutions.
- Measured the conductivity of both the binary solutions and the saturated Nafion membranes using a cell.
- Performed Fourier Transform Infrared (FTIR) spectroscopy on the saturated membranes.

Relationship between TMA and PN concentration (M)



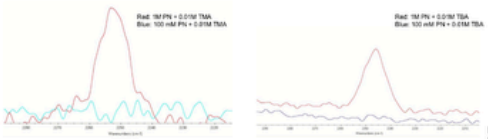
- Low concentration of PN and low concentration of TMA result in higher conductivity.

Relationship between TBA and PN concentration (M)



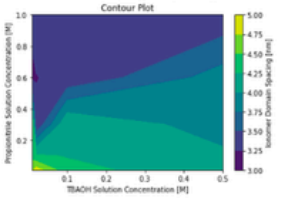
- High concentration of PN and low concentration of TBA result in low conductivity.

ATR-FTIR Absorbance



- PN absorption at PN solution concentration of 1M
- PN indirectly affects ionomer properties
- Similar results for both TBA and TMA

Ionomer Domain Spacing



- High PN concentration decreased ionomer domain spacing.
- Lower TBAOH and PN concentration increased the ionomer domain spacing.

Conclusion

- PN absorbed into Nafion-117 only at concentrations of 1 M.
- Increased PN concentration led to a decrease in ionomer domain spacing.
- The balance of concentrations impacts conductivity, suggesting an optimal range for efficient ion transport.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

Enzymatic Synthesis of Furan-Based Polymers

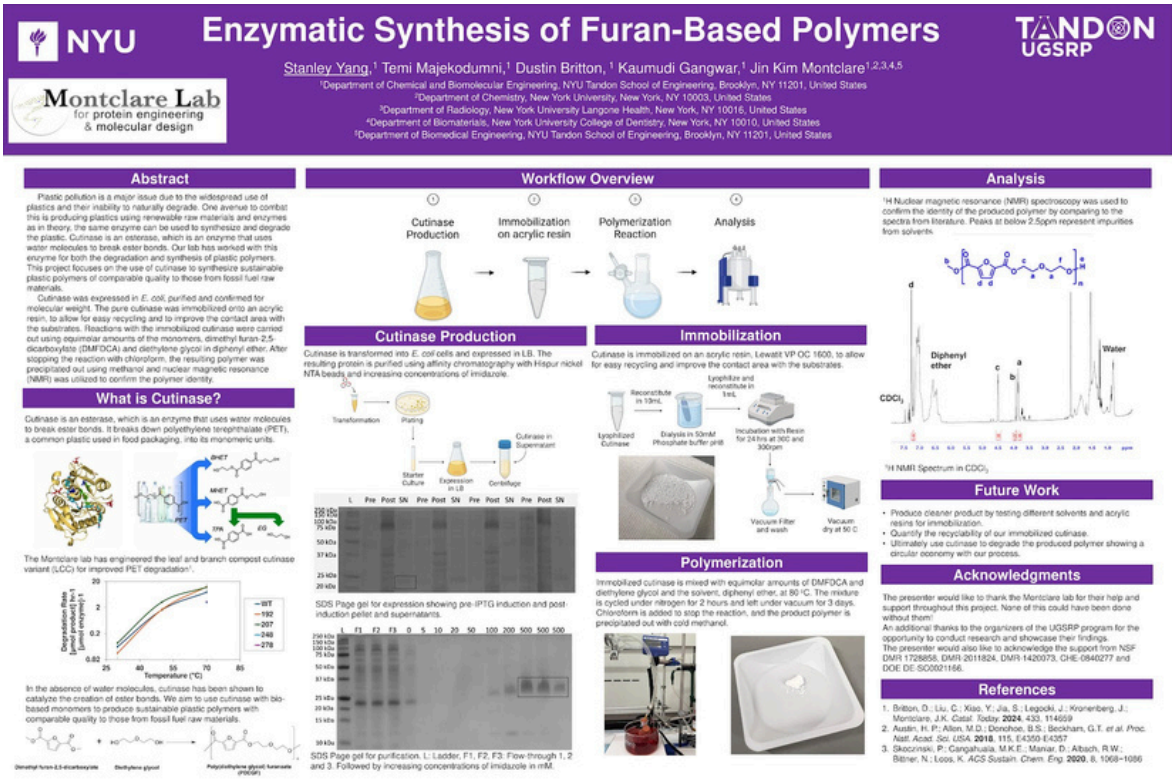
Plastic pollution is a major issue due to the widespread use of plastics and their inability to naturally degrade. One avenue to combat this is producing plastics using renewable raw materials and enzymes as in theory, the same enzyme can be used to synthesize and degrade the plastic. Cutinase is an 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.

Project Supervisor Jin Montclare

Research Areas Sustainability



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Metal-TFSI Doping MEH-PPV and the Impact of In-Plane Conductivity

Lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) is a commonly used dopant in the electronics industry. In solar cells, LiTFSI and oxygen are used to oxidize the host material and ensure stable p-type (electron deficient) character in the host material. This process results in significantly enhanced conductivity and device performance. The exact chemical pathways of this interaction are still not fully understood. In this project, various metal-TFSI salts are used to dope poly[2-methoxy-5-(2-ethylhexyloxy)-1,4- phenylenevinylene] (MEH-PPV) in the presence of UV light. The experiment is mainly carried out by spin-coating indium tin oxide (ITO) glass, which is a mixture of indium oxide (In2O3) and tin oxide (SnO2) with great electronic conduction property, and measuring the conductivity. The impact of cation composition, dopant concentration, and presence/absence of oxygen are studied in detail through UV-Vis spectroscopy, current-voltage measurements, and photoluminescence spectroscopy. It is observed that thin films of MEH-PPV containing metal-TFSI dopants demonstrate enhanced conductivity, and that this conductivity can be elevated further through exposure to UV light, resulting in a stable enhancement of the conductivity even when the light source is removed. Future work will probe the exact mechanism by which the conductivity enhancement occurs when exposed to UV light.

Project Supervisor André D. Taylor
Research Areas Sustainability
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Metal-TFSI doping of MEH-PPV and the impact on in-plane conductivity

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Department of Chemical and Biomolecular Engineering, Tandon School of Engineering, New York University

Abstract

When sunlight shines on semiconductor solar cells, through the photovoltaic effect, electron-hole pairs and a band gap are generated. The electrons will move to produce currents with enough solar energy. To improve the efficiency of current conduction, our goal is to change the density of electron-hole pairs by coating the semiconductor material with different doppants, while trying to find the element with the greatest improvments and other suitable conditions for further enhancement.

Background on the Project

Lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) is a commonly used dopant in the electronics industry. In solar cells, LiTFSI and oxygen are used to oxidize the host material and ensure stable p-type (electron deficient) character in the host material [1]. Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) used as solution carrier is a conductive organic semiconductor with low molecular weight and hydrophobic properties. The impact of cation composition, dopant concentration, and presence/absence of oxygen are studied through UV-Vis spectroscopy, current-voltage measurements, and photoluminescence spectroscopy.

Methodology

The experiment is mainly carried out by spin-coating ITO glass and measuring the conductivity. We collect and verify data and set standards based on existing paper materials. The corresponding data of current and voltage obtained is used in Python to calculate conductivity and draw box plots of different groups to compare the results. We primarily use the MEH-PPV solution with LiTFSI added and the pristine solution for comparison to determine the most suitable dopant concentration. We also try to study the inluence of UV light on improving conductivity and find the relationship between irradiation time and this improvement.To find the best dopants, different TFSI salts are added according to the proportion, such as Li, Mg, Cs, K, and La. The last stage is to explore tthe affect of he presence of oxygen on the coating and hybridization process by comparing the obtained data in the nitrogen environment in the glovebox and the data in the outside air.

Results

It is observed that thin films of MEH-PPV containing metal-TFSI dopants demonstrate improved conductivity. Started with LiTFSI, the experiments show that the substrates have the best performance if the concentration is 5ul.The conductivity can be elevated further through exposure to UV light, resulting in a stable enhancement of the conductivity even when the light source is removed.

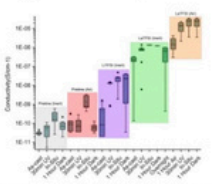


Figure 1: The Conductivity Results for Different Sets of Substrates Under Different Conditions

According to Figure 1, the mentioned increasing trend can be seen in the data of each group of substrates, and the value will decrease after the irradiation is canceled, but will not drop to the initial value. Compared with other dopants, the effect of La element doping is the most obvious. After the participation of oxygen in the reaction, the conductivity is further improved, and in subsequent experiments, we also found that other elements will degrade in the air after doping, while La is very stable.

However, we did not plot the exact situation of LiTFSI substrates in air. As shown in Figure 2, the voltage and current are not linear when measuring the data, and without a stable resistance, the conductivity cannot be calculated accurately.

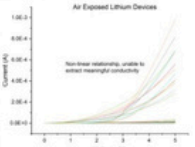


Figure 2: Voltage-Current Plot for Aired Exposed Lithium Devices

Future Work

The subsequent research will probe the exact mechanism by which the conductivity enhancement occurs when exposed to UV light through UV-Vis spectroscopy, and explore how to achieve optimal film thickness and uniform distribution.

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Acknowledgement

The author would thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project, extend deepest gratitude to the project advisor, Professor Andre Taylor, with his help, and acknowledge the dedicated support and guidance from the research mentor, Seth McPherson.

Developing Automatic VOC Leakage Detection Robot with NVIDIA Jetson Orin Nano

Volatile organic compounds (VOCs) are gases that emanate from solids and liquids. Many VOCs are harmful to humans. Chemical plants and biochemical laboratories are high-risk areas for VOC leaks. In this project, a robot equipped with an Nvidia Jetson Orin Nano minicomputer, a high-performance microcomputer supporting GPU-accelerated computing, and an SGP-40 VOC sensor will perform VOC (simulated in ethanol) leakage sensing and reporting experiments in a biochemical laboratory with a complex airflow field. Mainstream chemical plants and biochemical laboratories adopt an upward air ventilation mechanism, so the VOC concentration varies more significantly in higher spaces, allowing for more effective localization of the leakage source. When the robot is in operation, it stops every one to two meters to use the heightened SGP-40 VOC sensor platform to sniff the VOC concentration for five minutes. When the VOC concentration shows a high value, the robot will rotate to recognize and report the suspected leak source instrumentation through a pre-trained plus transfer learned ResNet-50 machine vision network, which is a CNN architecture that belongs to the ResNet (Residual Networks) family, a series of models designed to address the challenges associated with training deep neural networks and object detection. The system has a high recognition accuracy of 90% to 95% and can be further improved with the use of larger training sets. This project has the potential to improve the efficiency of VOC leak detection in the industry, reduce the overhead of the detection process, and safeguard the personal safety of workers during detection efforts.

Project Supervisor Xin Wang

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Develop an Automatic VOC Leakage Detection Robot with NVIDIA Jetson Orin Nano

Terry Mu[1], Xin Wang[2]

1. NYU Tandon Computer Science Department 2. NYU Tandon Chemical and Biomolecular Engineering Department

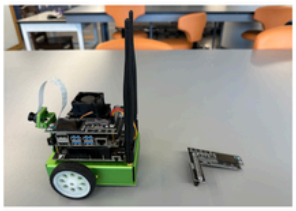


Figure 1: The Jetson Orin Nano robot and the sensor module.

Abstract

The goal of this project is to develop an automatic robot that is capable of detecting volatile organic compounds (VOC) leakage, locating the possible device that leaks the VOC, and identifying and reporting the name of the device in the complex ventilation environments of laboratories and chemical plants.

Background

Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids, and most of VOCs are adverse to humans and may cause cancer. Rapid detection of VOC leaks is important. Therefore, the development of a more automated and miniaturised robot is necessary compared to traditionally using sensors, which are less effective and human-involved.

Methodology

- A SGP-40 VOC sensor was used to measure the concentration of the raw gas.
- Ethanol was used to simulate VOC leakage.
- In order to simulate the complex ventilation environment, all measurements and experiments were carried out in a biosafety level 2 standard laboratory.
- A fan was used to create an "artificial" VOC concentration gradient because the normal VOC diffusion concentration gradient was disrupted by the disturbed flow of the ventilation system.
- Two ResNet-18 convolutional neural networks are used for obstacle avoidance and recognition of instruments, respectively.
- Another CNN is trained to determine the distance from the source of the leak by means of a graph drawn from the data sampled over a period of time.

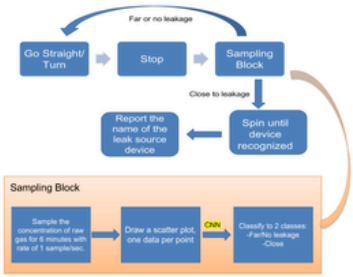


Figure 2: Operational logic of the robot

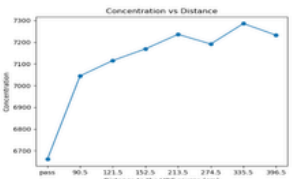


Figure 3: The concentration gradient created by the fan. The further away from the fan the lower the air velocity, the more VOC molecules will gather at a distance, so the farther away from the VOC the higher the concentration.

Conclusion and Future Work

- With the airflow created by the fan, a stable concentration gradient was created (Figure 3).
- The robot can move and identify the devices that appeared in the laboratory.
- Two CNNs were trained to determine the distance from the concentration plot. With a test set of 20 plots:
  - Using AlexNet (a light-weighted visual CNN model), the accuracy was 90%
  - Using ResNet-18, the accuracy was 95%.
- Some mechanical problems of the robot were found, thus a better speed control system can be implemented.
- Because most ventilation systems draw air upwards, the sensor can be elevated to capture more accurate VOC concentrations.
- To further improve the performance of the plot recognition CNN, the train set should be enlarged.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks to Xin Wang for supervising and leading the project.

Characterization of Quantum Cutting Materials to Increase Silicon Solar Cell Efficiencies

Silicon solar cells are widely used to capture solar energy; however, its efficiency is not maximized due to the predominantly ultraviolet (UV) photons emitted by the sun. Solar cells can be improved using quantum cutting techniques where one high energy UV photon is converted into two or more near-infrared (NIR) photons with lower energy in a region where silicon solar cells are efficient at converting solar energy into electrical energy.

The main focus of this research was on the characterization of ytterbium (Yb)-doped perovskite films. Using the perovskites Cs2AgBiCl6 and CsPbCl3 doped with Yb, photoluminescence quantum yield (PLQY), time-resolved photoluminescence (TRPL), UV-Vis, visible PL, and XRD were performed on each film. PLQY involves shining UV photons on the film and finding the ratio of NIR photons emitted as a percentage compared to UV photons absorbed. TRPL determines and measures the decay of photoluminescence (PL) as a function of time. XRD consists of a nondestructive technique that provides detailed information about the crystallographic structure, chemical composition, and physical properties of the material tested. It was discovered that annealing the Cs2AgBiCl6 films in air on a hot plate creates irreproducibility and instability in the results. Additionally, tests were done to observe the effects of the orientation of small, square films (15 cm x 15 cm) placed in the PLQY sphere. It was found that each orientation with respect to the UV source (right, bottom, left, top) produced different PLQY efficiencies with a standard deviation of 8%. The highest PLQY efficiency achieved for theYb-doped Cs2AgBiCl6 films is 55%. Different synthesis techniques led to a similar result. Further research is required to understand the cause of the fluctuations in the efficiency. Therefore, with further research, ytterbium-doped Cs2AgBiCl6 could be a promising addition to the current silicon solar cells to successfully increase the efficiency.

Project Supervisor Eray Aydil

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Characterization of Perovskite Films: Improving Solar Cell Efficiencies

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Abstract

Perovskite films are emerging as a method to improve solar cell efficiency. When doped with ytterbium (Yb), these films have a potential to achieve quantum cutting. This research focused on characterization of the perovskite films. Different variables (annealing time, annealing temperature, environment, etc.) are varied in the preparation and synthesis of the films and trials were done to determine trends and gather data on the effects of these variables on the efficiency and structure of the films.

Background

Current silicon solar cells are only able to convert around 33.6% of solar energy into electrical energy [1]. Quantum cutting is a phenomenon where a high energy UV photon is converted into two lower energy IR photons that can be fully utilized by the silicon solar cells. This research specifically focuses on $Cs_2AgBiCl_6$ and $CsPbCl_3$, doped with ytterbium. The films are synthesized using a physical vapor deposition (PVD) method that evaporates chemical powders, allowing them to react before depositing on a glass substrate.

Methods

Photoluminescence quantum yield (PLQY) was used for the purpose of measuring and comparing the ratio of the photons that are emitted per photons absorbed. When designing new films, PLQY consisted of having an excitation source, which can act as a laser or LED. The light then hits the luminescent sample located in an integrated sphere measuring both excitation and emission scan.

Time-resolved photoluminescence (TRPL) was used for the purpose of evaluating the effect of photonic structures on the lifetime of the film. Two excitation wavelengths are used to evaluate the quality of the bulk and patterns of the surface of the film.

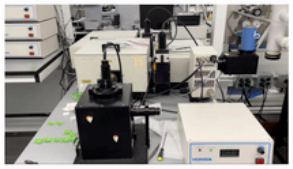


Figure 1: PLQY and TRPL equipment used to test $Cs_2AgBiCl_6$ and $CsPbCl_3$ films

X-Ray Diffraction (XRD) was also performed on our films which consisted of a nondestructive technique that provides detailed information about the crystallographic structure, chemical composition, and physical properties of the material tested.



Figure 2: X-Ray Diffraction on $Cs_2AgBiCl_6$ films

Results

In one study, PLQY results show that the samples peak when doped with 8% Yb. Another study determined that 30% excess bismuth chloride consistently provided the highest PLQY, varying minimally with annealing times.

XRD testing showed that samples annealed in the glovebox at 250°C had peaks matching the position of those in $Cs_2AgBiCl_6$, while films annealed in air at 250°C contained impurities.

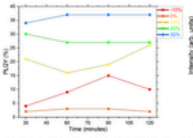


Figure 3: Excess bismuth chloride PLQY results

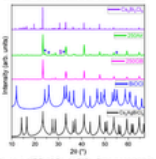


Figure 4: XRD of $Cs_2AgBiCl_6$ films annealed in different environments

Conclusion and Future Work

In conclusion, Yb-doped perovskite films have the potential to increase solar cell efficiency using quantum cutting. More research regarding the methods used to create the films under various conditions needs to be done in order to optimize the efficiency.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. We would also like to thank our project supervisor, Prof. Eray Aydil, and our mentors, Pulkita Jain and Seda Sarp.

Assessment of Sustainable Engineering Education in Higher Education

As the issues of environmental sustainability intensify due to rapid climate changes and pressing social issues, the value of sustainability in engineering education has become more apparent. Our research investigates the integration and effectiveness of sustainability education within engineering programs at NYU Tandon. Employing a mixed method research design, our study uses both quantitative surveys and qualitative interviews to offer a thorough evaluation of the current sustainability curriculum and extracurricular activities.

Project Supervisor Ingrid Paredes

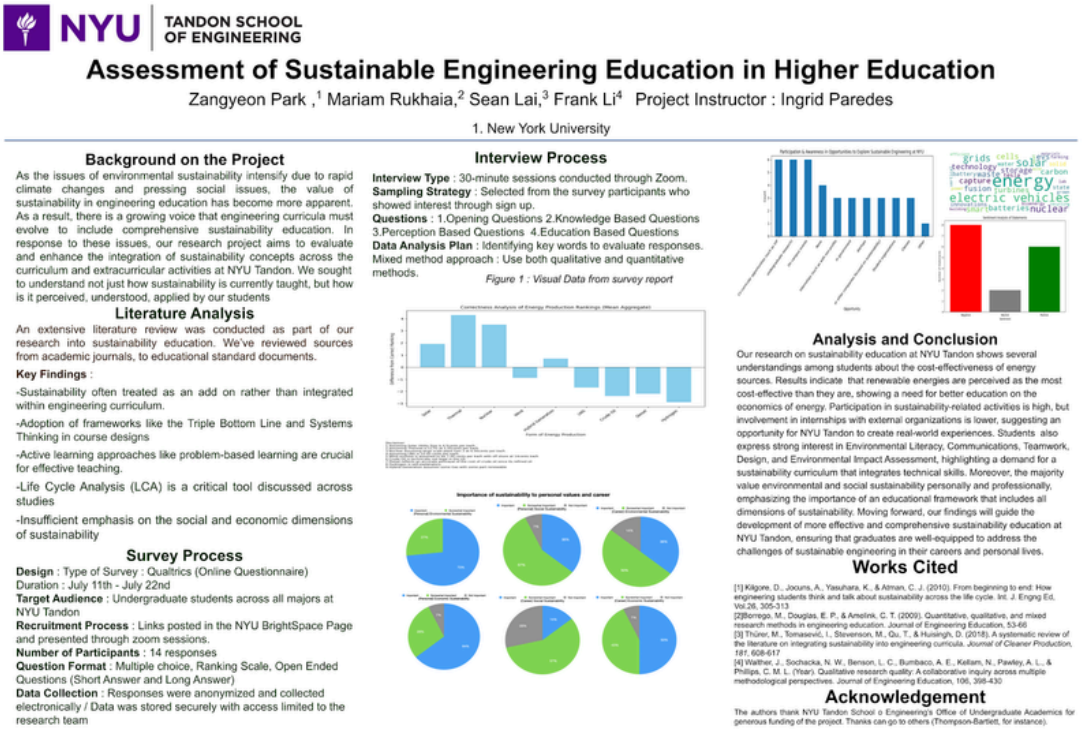
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NYU TANDON SCHOOL OF ENGINEERING

Assessment of Sustainable Engineering Education in Higher Education

Zangyeon Park ,[1] Mariam Rukhaia,[2] Sean Lai,[3] Frank Li[4] Project Instructor : Ingrid Paredes

1. New York University

Background on the Project

As the issues of environmental sustainability intensify due to rapid climate changes and pressing social issues, the value of sustainability in engineering education has become more apparent. As a result, there is a growing voice that engineering curricula must evolve to include comprehensive sustainability education. In response to these issues, our research project aims to evaluate and enhance the integration of sustainability concepts across the curriculum and extracurricular activities at NYU Tandon. We sought to understand not just how sustainability is currently taught, but how is it perceived, understood, applied by our students

Literature Analysis

An extensive literature review was conducted as part of our research into sustainability education. We've reviewed sources from academic journals, to educational standard documents.

Key Findings :

-Sustainability often treated as an add on rather than integrated within engineering curriculum.

-Adoption of frameworks like the Triple Bottom Line and Systems Thinking in course designs

-Active learning approaches like problem-based learning are crucial for effective teaching.

-Life Cycle Analysis (LCA) is a critical tool discussed across studies

-Insufficient emphasis on the social and economic dimensions of sustainability

Survey Process

Design : Type of Survey : Qualtrics (Online Questionnaire)
Duration : July 11th - July 22nd
Target Audience : Undergraduate students across all majors at NYU Tandon
Recruitment Process : Links posted in the NYU BrightSpace Page and presented through zoom sessions.
Number of Participants : 14 responses
Question Format : Multiple choice, Ranking Scale, Open Ended Questions (Short Answer and Long Answer)
Data Collection : Responses were anonymized and collected electronically / Data was stored securely with access limited to the research team

Interview Process

Interview Type : 30-minute sessions conducted through Zoom.
Sampling Strategy : Selected from the survey participants who showed interest through sign up.
Questions : 1.Opening Questions 2.Knowledge Based Questions 3.Perception Based Questions 4.Education Based Questions
Data Analysis Plan : Identifying key words to evaluate responses.
Mixed method approach : Use both qualitative and quantitative methods.

Figure 1 : Visual Data from survey report

Analysis and Conclusion

Our research on sustainability education at NYU Tandon shows several understandings among students about the cost-effectiveness of energy sources. Results indicate that renewable energies are perceived as the most cost-effective than they are, showing a need for better education on the economics of energy. Participation in sustainability-related activities is high, but involvement in internships with external organizations is lower, suggesting an opportunity for NYU Tandon to create real-world experiences. Students also express strong interest in Environmental Literacy, Communications, Teamwork, Design, and Environmental Impact Assessment, highlighting a demand for a sustainability curriculum that integrates technical skills. Moreover, the majority value environmental and social sustainability personally and professionally, emphasizing the importance of an educational framework that includes all dimensions of sustainability. Moving forward, our findings will guide the development of more effective and comprehensive sustainability education at NYU Tandon, ensuring that graduates are well-equipped to address the challenges of sustainable engineering in their careers and personal lives.

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[3] Thürer, M., Tomašević, I., Stevenson, M., Qu, T., & Huisingh, D. (2018). A systematic review of the literature on integrating sustainability into engineering curricula. Journal of Cleaner Production, 187, 608-617.
[4] Walther, J., Sochacka, N. W., Benson, L. C., Bumbaco, A. E., Kellam, N., Pawley, A. L., & Phillips, C. M. L. (Year). Qualitative research quality: A collaborative inquiry across multiple methodological perspectives. Journal of Engineering Education, 106, 398-430

Acknowledgement

The authors thank NYU Tandon School o Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks can go to others (Thompson-Bartlett, for instance).

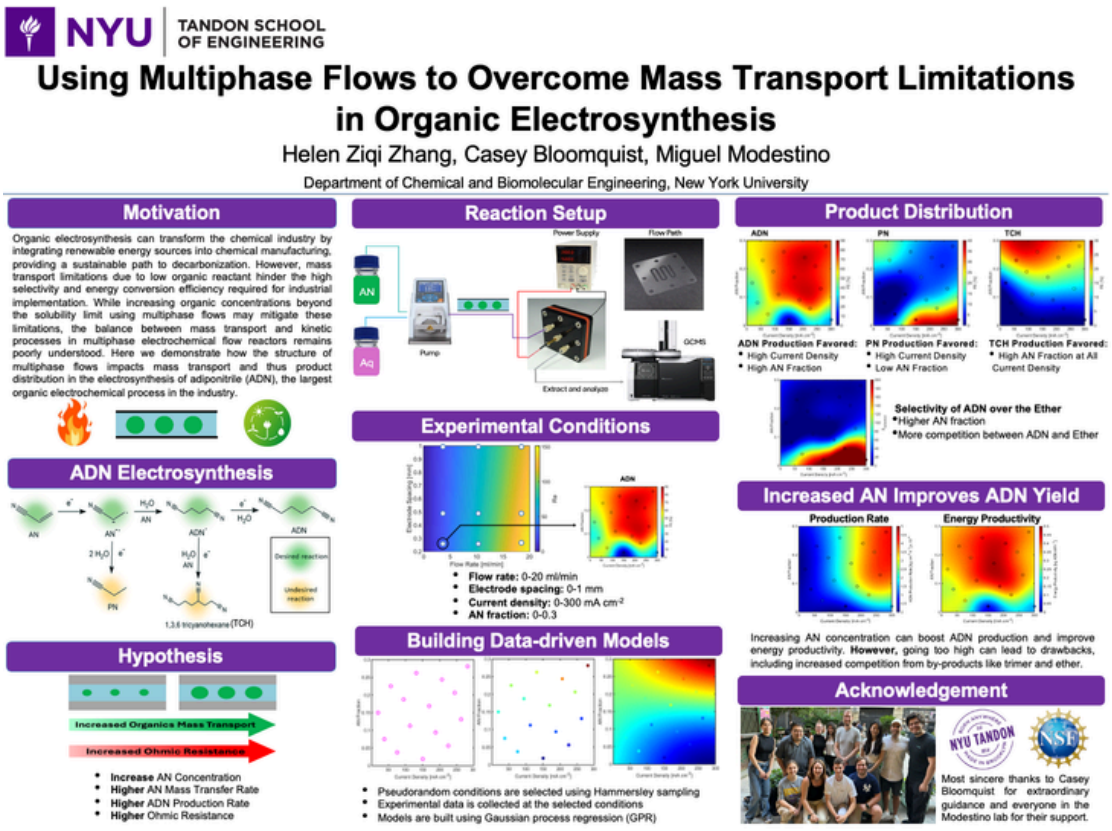
Using Multiphase Flows to Overcome Mass Transport Limitations in Organic Electrosynthesis

Organic electrosynthesis can transform the chemical industry by integrating renewable energy sources into chemical manufacturing, providing a sustainable path to decarbonization. However, mass transport limitations due to low organic compound solubility in aqueous electrolytes hinder the high selectivity and energy conversion efficiency required for industrial implementation. While increasing organic concentrations beyond the solubility limit using multiphase flows may mitigate these limitations, the balance between mass transport and kinetic processes in multiphase electrochemical flow reactors remains poorly understood. Here we demonstrate how the structure of multiphase flows impacts mass transport and thus product distribution in the electrosynthesis of adiponitrile, one of the largest organic electrochemical processes in the industry. We find that higher reactant concentrations lead to increased adiponitrile yields. However, exceeding the solubility limit with multiphase flows can impair reactor performance through undesired byproducts and increased ohmic resistance. Using these insights, we derive design guidelines for multiphase flows that optimize energy efficiency at high conversion rates, contributing to greener manufacturing practices in the chemical industry.

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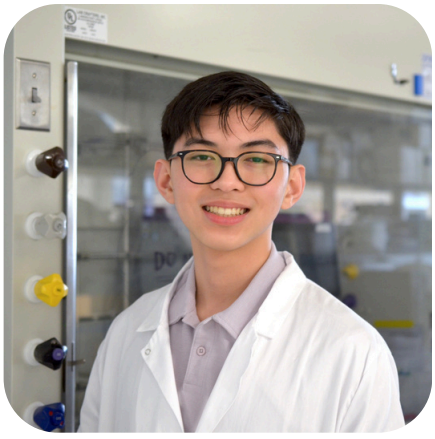
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Chemical and Biomolecular Engineering, B.S.
Spring 2025
NYU Tandon

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 150, with this year setting a record at 151 participants!

Our program includes a diverse array of faculty and research projects over the years offered from prestigious groups such as NYU Wireless, the NYU Center for Urban Science and Progress, NYU Langone, the Center of Faculty Innovations in Teaching and Learning (FITL), the Makerspace, and various Vertically Integrated Program (VIP) projects.

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 enhancing this program at every turn is 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.



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