

NYU | TANDON

2023

SEVENTEENTH ANNUAL

UNDERGRADUATE SUMMER RESEARCH PROGRAM ABSTRACTS

2023 SUMMER RESEARCH



NYU Tandon School of Engineering's Undergraduate Summer Research Program (UGSRP) provides a unique opportunity for NYU Tandon, NYU Abu Dhabi, NYU Shanghai, NYU College of Arts and Science + NYU Tandon 3+2 Dual Degree Program, and other select students to engage in research over the course of the summer months. This program offers far more than the traditional classroom experience; it allows students to work alongside faculty mentors, PhD and masters students, as well as research staff on cutting-edge research projects. Aside from this, they get to interact with other students of all different levels from various fields of study within NYU and outside over a 10-week period. Aiming to enhance and broaden students' knowledge base by applying classroom learning to solve practical and contemporary problems, this program prepares all participants for lifelong learning.

Close interaction with faculty and research staff promotes an educational experience that advances Tandon's i2e model of invention, innovation and entrepreneurship. As such, participation in this program from faculty and other project supervisors is essential. Along with the faculty, other Research Staff have extensively mentored the students, helping them to learn what research is and what the best practices are for their specific subject areas. In addition to the research performed, students participate in various workshops, lectures, and seminars throughout the summer. The Dibner Library joined the program for the fifth year to provide the Student2Scholar (S2S) Series, where students learn more about moving towards scholarship. A tremendous thanks to them as well as the other guest speakers and sessions that provided the students with pertinent information and resources to ensure their future success. Detailed information is included of each event and the presenters are included later within this booklet.

Financial support from NYU Tandon, faculty research grants, and outside donors is also essential to the program's continuation. This year marked the 12th year of the Thompson-Bartlett (TB) Fellowship. Ten of this summer's female researchers were graciously supported through this fellowship, made possible by Mrs. Dede Bartlett whose father, Mr. George Juul Thompson, was a graduate of the Electrical Engineering program at the Polytechnic Institute of Brooklyn in 1930. We are thrilled to celebrate the 100th Scholar has been awarded through the Fellowship this summer. My infinite thanks goes out to Dede for her extended support of our women participants. The program houses additional fellowships, including the Tandon Scholars Fellowship, and the Visiting Student Fellowship. Like Dede and the funding for these fellowships, donors' gifts allow us to engage more student researchers, faculty mentors, and further strengthen this truly unique summer experience.

The coordination of this program takes a large amount of effort. I would like to acknowledge Sara-Lee Ramsawak, Senior Director of Academics, Programs, & Global Engagement, who oversees the UGSRP and manages the booklet production. She has been a part of the programs' coordination efforts since 2013. Sophie Chlasma worked under Sara to compile his year's Abstract Booklet. Jen Piro, Associate Director of Undergraduate Programs, joined in on the coordination efforts in 2019 and took charge of the program's administration, especially the summer participant placements. Kat Arrendondo, Tandon's UGA Program Administrator joined in on the coordination of the program last year and spearheaded the calendar of events, specifically working to create new opportunities for engagement with PhD students and social interactions between participants. She worked with two amazing Graduate Assistants – Mohamed Asran and Cynthia Guan. A big, big thanks to the team!

This summer, students had the opportunity to participate in both in-person research on campus at NYU and remote research from home. The seminars, workshops, and events were held in various different formats - virtually, in-person, and hybrid. At the end of the program, all students participated in a video presentation event where the most creative presentations and those with the best pitch were chosen as winners. The abstracts published in this year's volume are representative of the research done this summer and celebrate the accomplishments of our undergraduate researchers. Congrats to all of the student researchers who participated in the 2023 UGSRP, thanks to the Research Mentors & Staff, Dede Bartlett, and the Library team, along with our coordinators and guest speakers. I am extremely satisfied with this program and I look forward to future summers of continued intellectual and scholarly activities!

Peter J. Voltz

Peter Voltz
Vice Dean for Academics

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Sameer Upadhye
Huishu Wang
Xuchu Xu
Anbang Yang
Ruixuan Zhang
Hanwen Zhao

CALENDAR OF EVENTS

JUN 5

Program Orientation
Jen Piro & Kat Arredondo

JUN 6

Lab Safety Training
Kay & Tarik

JUN 7 to AUG 10

Student to Scholar Series (S2S)
Dibner Library Team: Matthew Frenkel, Sam Putnam, & Lindsey Anderberg

- What is Research?
- Developing a Literature Review
- Project Management Workshop
- Ethics in Research
- Developing a Research Proposal
- Writing a Research Statement
- Writing for Publication
- Constructing a Research Poster
- Presenting Research

JUN 15

MakerSpace Session
Molly Ritmiller

JUN 22

UGSRP Networking Mixer
UGA Office

JUN 29

NSF Graduate Research Fellowship Program
Jamie Lloyd

JUL 6

PhD Panel
Jamie Lloyd

JUL 20

Portfolio Development Workshop
Molly Ritmiller

JUL 27 & 28

Poster Critique Sessions
Dibner Library Team

AUG 3

How to Showcase Academic Projects on Your Resume
Jolie Woodson

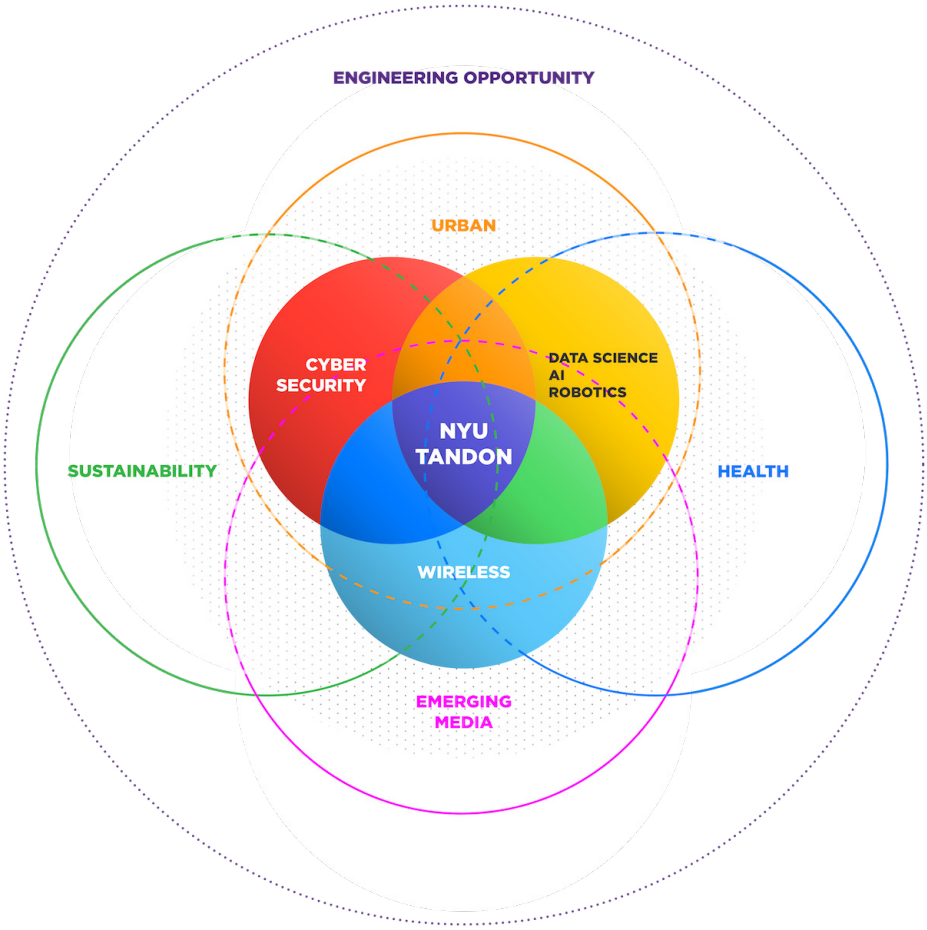
AUG 9

Culminating Event
Sara-Lee Ramsawak, Jen Piro, & Kat Arredondo
with the assistance of Mohamed Asran, Natalie Baigorria, Cynthia Guan, and Shahzaib Zamir


NYU
TANDON SCHOOL
OF ENGINEERING
Polytechnic Institute

AREAS OF EXCELLENCE

NYU Tandon is engineering creative and smart, connected and secure, sustainable and healthy urban communities.



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. The Undergraduate Summer Research Program projects are all situated within these different areas of research.

UGSRP FELLOWSHIPS

The Undergraduate Summer Research Program is funded by various different entities across NYU, including both internal and external funding. Thank you to all of the donors who support the program. Thanks also to faculty who support UGSRP students through their grants. Some of the funds used for the programs go towards placing students into specialized fellowships.

THOMPSON-BARTLETT FELLOWSHIP

- Supports summer research internships for ten outstanding female undergraduate students.
- Access to additional events and opportunities.
- Sponsored by Dede Bartlett, a career coach to thousands of college and graduate students across the U.S.A. Her lectures on career and work/life issues are drawn from her impressive background as a senior officer with two Fortune 500 companies.

SCHOLARS FELLOWSHIP

- Supports all Tandon GLASS Program Honors students within the UGSRP
- Access to additional funding for supplies and conferences as well as the possibility of housing

VISITING STUDENT FELLOWSHIP

- Supports non-NYU students within the UGSRP
- Allows for entry from students outside of the University
- Access to additional funding for housing

THOMPSON-BARTLETT FELLOWSHIP

The Thompson-Bartlett Summer Research Fellowship supports summer research internships for outstanding women undergraduate students across majors at NYU Tandon, especially those majoring in CBE, CS, EE, ECE, ME or PH or who plan to pursue projects related to STEM fields. The selected students will have the opportunity to get involved in cutting-edge research with NYU School of Engineering faculty for 10 weeks through the Undergraduate Summer Research Program. The positions are paid, full-time internships.

Qualified students that apply for Undergraduate Summer Research Program are automatically considered for the fellowship. Recipients of this award will be compensated for the summer and will be recognized as Thompson-Bartlett Summer Research Fellows granting them access to other events and opportunities.



About the Donor

Dede Bartlett is a career coach to thousands of college and graduate students across the U.S.A. Her lectures on career and work/life issues are drawn from her impressive background as a senior officer with two Fortune 500 companies – Exxon Mobil and Altria – a Trustee of the Woodrow Wilson National Fellowship Foundation, a Director of A Better Chance, and the Immediate Past Chair of the Advisory Board of the National Domestic Violence Hotline. Dede Bartlett was Vice President of Corporate Affairs Programs at Altria Group, Inc. where she developed the Company's award-winning domestic violence education programs and produced more than 40 conferences around the world. She was also Vice President and Corporate Secretary of the Company. Earlier, she served as Corporate Secretary of Mobil Corporation, Assistant to the Chairman and CEO, President of Mobil Foundation and Chair of the Board's Contributions Committee. Mrs. Bartlett has received The Woman Who Makes a Difference Award from the International Women's Forum and has been honored by Lifetime Television, the National Center for Victims of Crime, the National Council of Jewish Women and the Center Against Domestic Violence. The mother of a daughter and son with advanced degrees, she is an honors graduate of Vassar College, holds a Masters Degree from New York University and is a former trustee of the American University of Central Asia. She and her husband live in Connecticut.

Ms. Bartlett established this summer research stipend in honor of her father, George Juul Thompson, a 1930 graduate of Polytechnic Institute of Brooklyn. After completing his B.S. degree in Electrical Engineering, Mr. Thompson had a distinguished career with General Electric, the Naval Applied Science Laboratory in Brooklyn's Naval Shipyard, and with the Naval Ship Research & Development Center in Annapolis, MD. In 1969, he received the Meritorious Civilian Service Award from the Department of the Navy. From 1948-1968, Mr. Thompson also served as a part-time instructor in Polytechnic's department of Electrical Engineering.

CELEBRATING 100 STUDENT FELLOWS

On July 11, 2023, Dede Bartlett joined Thompson-Bartlett Fellowship alumni, current fellows, and administration for a dinner at NYU Tandon to celebrate the Fellowship reaching 100 student fellows in 2023.



Dede spoke to the Thompson-Bartlett Fellows about the history of the fellowship, the opportunities it can provide, and her excitement for events like this one.



Nicole Johnson led the Fellows in a discussion about their current and past projects and the opportunities afforded to them by the Fellowship.



STUDENT RESEARCH REIMAGINED

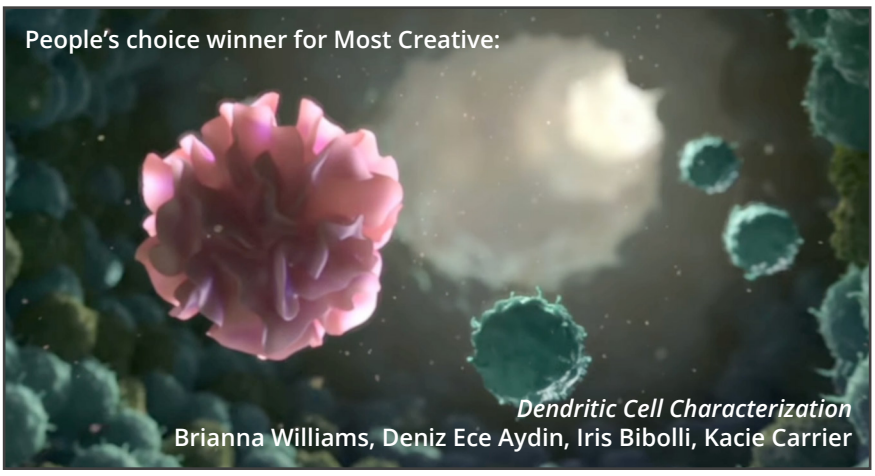
The Tandon Undergraduate Summer Research Program recently held its culminating event, where students showcased their research through video presentations in which all research participants created a video about their summer research project geared toward a "non-STEM" audience. The event featured two award categories: Most Creative and Best Pitch, each recognizing different aspects of the students' presentations.

The Most Creative award category aimed to acknowledge the undergraduate research video presentation that exhibited the most innovative and imaginative approach in delivering their research findings. Students in this category went beyond conventional methods of presentation and incorporated unique visual elements, storytelling techniques, or interactive elements to engage and captivate the audience. This category sought to reward students who showed the ability to think outside the box and bring a fresh perspective to their research. By challenging traditional presentation methods, these students demonstrated their creativity and ability to stand out.

On the other hand, the Best Pitch award category valued the undergraduate research video presentation that effectively communicated the research topic, objectives, and significance in a concise and compelling manner. This category sought to recognize the presentation with the most persuasive and impactful delivery – a presentation that could capture the attention of the audience from the start. The winning presentation excelled in clearly and concisely conveying the project's importance, allowing the audience to understand the research's value and potential impact. The Best Pitch category celebrated the students' ability to effectively pitch their research, showcasing their communication skills and their ability to articulate complex topics in an accessible and compelling way.

Overall, the culminating event of the Tandon Undergraduate Summer Research Program was a testament to the students' hard work and dedication in their research endeavors. The award categories of Most Creative and Best Pitch highlighted different strengths in the students' presentations, recognizing those who brought a fresh perspective to their research and those who were able to effectively convey the significance of their work.

The winners are listed on the following page, and their videos can be viewed here.





People's choice winner for Best Pitch:
Light Interactions with Fast Charging Lithium-Ion Battery Electrodes
Ariel Suynov

STUDENT RESEARCH REIMAGINED

MOST CREATIVE

First Place

"Aquatic Photodegradation of Pesticides"
Sadiya Hossain, Zoë Herman
Supervisor: Dr. Andrea Silverman
Mentor: Luana de Brito Anton

"Dendritic Cell Characterization"
Brianna Williams, Deniz Ece Aydin, Iris Bibolli, Kacie Carrier
Supervisor: David Truong
Mentors: Minjoo Kim, Serena Francesca Generoso

"Connections in Crime Rates Across NYC"
Rasheed Hossain
Supervisor: Maurizio Porfiri
Mentor: Rayan Succar

Second Place

"Metaverse For Education"
Nabiha Siddique, Jason Mai, Tina Chibane
Supervisor: Dzung Luong

"Utilizing Microfluidics and Dean Flow-Focusing for Efficient Spectroscopic Analysis of Microplastics"
Phin Ariyaphuttarat
Supervisor: Ryan L. Hartman

"The Robotization of the Waddle"
Ka Seng Soo
Supervisor: Joo H. Kim
Mentor: Stacy Ashlyn, Hyunjong Song, Sameer Upadhye

Third Place

"Light Responsive Nanoparticles for Drug Delivery"
Vic M. Hempstead
Supervisor: Nathalie Pinkerton
Mentor: Amy Moreno

"IRES Feasibility Investigation of 3D Printable Bio-Polymer"
Kayla Andersen
Supervisor: Nikhil Gupta
Mentor: Caleb Beckwith

"Video Analytics of Traffic Safety Research"
Lukelo Thadei Luoga
Supervisor: Karan Ozbay
Mentors: Fan Zuo, Jingqin Gao

BEST PITCH

First Place

"Folic Acid Supplementation"
Amisha K. Gopee, Rosanne Cui, Aya Ibrahim
Supervisor: Richard A. Stein

"Light interactions with fast charging lithium-ion battery electrodes"
Ariel Suynov
Supervisor: Andre Taylor
Mentor: Yaxin Shen

"Urban Rainfall Assessment through Analysis of Open Data"
Genevieve Beirne
Supervisor: Debra Laefer

Second Place

"Competitive Reinforcement Learning as a Sequence Modeling Problem"
Juan Guevara
Supervisor: Quanyan Zhu

"At Home Iron Level Detection Using Salivary Ferritin"
Amulya Hota, Basia Alexandra Fellner-Dublin
Supervisor: Jin Ryoun Kim

"Floodnet"
Ashok Timsina, Jax Li
Supervisor: Andrea Silverman
Mentor: Charlie Mydlarz

Third Place

"Roadway Flood Detection Model"
Grace Liu
Supervisor: Kaan Ozbay
Mentors: Fan Zuo, Jingqin Gao

"Low Power Computer Vision"
Malik Usaid, Gaurang Ruparelia, Ben Bayor & Ammaar Firozi
Supevisor: Chen Fang
Mentor: Abdulaziz Alaql

"Building Heuristics for Accessible XR"
Cindy Liu & Christine Wang
Supervisor: Regine Gilbert

Most Creative: People's Choice

"Dendritic Cell Characterization"

Brianna Williams, Deniz Ece Aydin, Iris Bibolli, Kacie Carrier
Supervisor: David Truong
Mentors: Minjoo Kim, Serena Francesca Generoso

Best Pitch: People's Choice

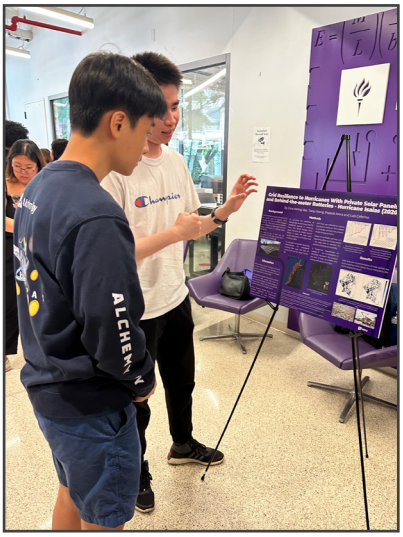
"Light interactions with fast charging lithium-ion battery electrodes"
Ariel Suynov
Supervisor: Andre Taylor
Mentor: Yaxin Shen

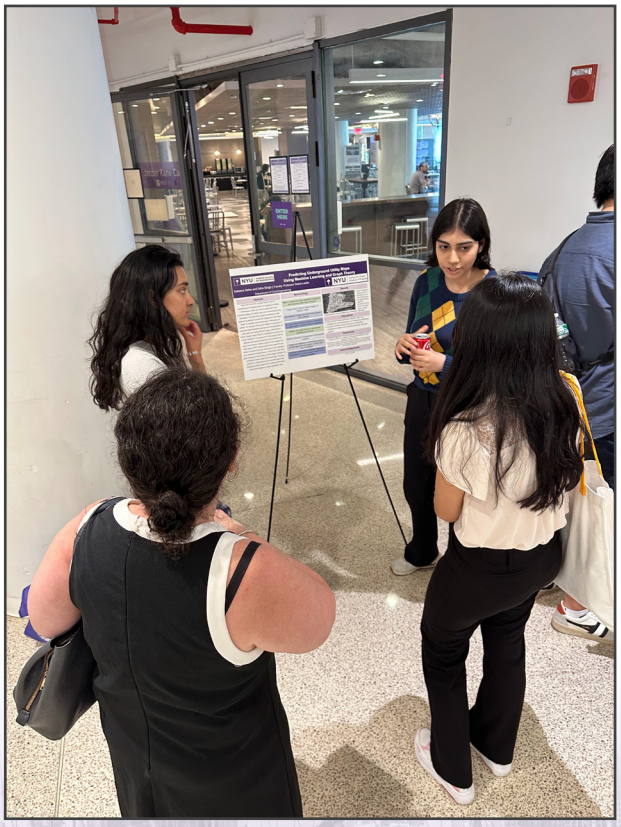
POSTER SESSION

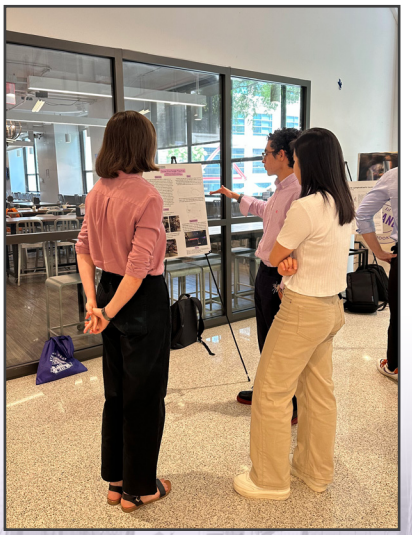














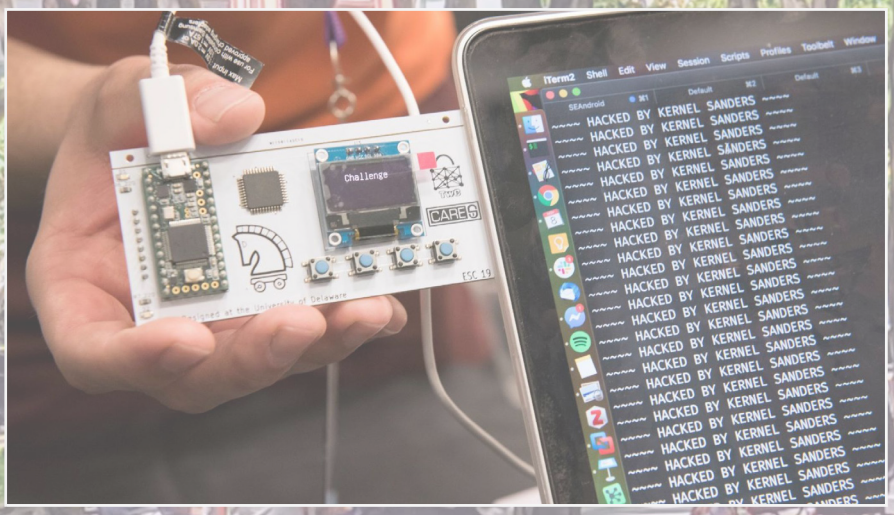

CYBERSECURITY
DATA SCIENCE/AI/ROBOTICS
EMERGING MEDIA
HEALTH
SUSTAINABILITY
URBAN
WIRELESS

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.

FACULTY

Justin Cappos (CSE)
Nikhil Gupta (MAE)



LEARN MORE

IRES ADDITIVE MANUFACTURING OF SOLAR CELLS

The Carbon-based perovskite solar cells (CPSCs) promise to revolutionize solar energy technology by offering higher efficiency and lower production costs than current alternatives. CPSCs face issues, such as poor infiltration of materials due to uncontrolled porosity and high-temperature processing required in fabrication. This limits the selection of compatible materials and restricts the possibilities for improvements. The use of ink/paste extrusion-based 3D printing techniques is used to overcome these limitations because it enables precise control over porosity during device fabrication. Exploring parametric optimization will allow for the successful implementation of this technology, opening up new opportunities for large-scale and cost-effective solar cell production, which drives the transition toward sustainable energy sources. This research also holds significance for the broader field of additive manufacturing, showcasing its potential to revolutionize materials science and renewable energy technology.

Project Supervisor: Dr. Nikhil Gupta (MAE); **Faculty Mentors**: Dr. Akm Shamsur Rahman, Dr. Mrityunjay Doddamani; **Research Staff:** Caleb Beckwith; Other Collaborators: Krishna Sharma, Satyam Choubey

Research Area: *Cybersecurity*



Sahil Krishnani
Mechanical Engineering, B.S., 2026
NYU Tandon School of Engineering



IRES Additive Manufacturing for Solar Cells

Sahil Krishnani[1], Krishna Sharma[2],Satyam Choubey[3]

1. New York University, 2. National Institute of Technology at Jalandhar 3. SRM Institute of Science and Technology at Chennai,

PI: Dr. Nikhil Gupta; Mentors: Dr. AKM Samsur Rahman, Dr. Mrityunjay Doddamani, Caleb Beckwith

NYU TANDON SCHOOL OF ENGINEERING

Abstract

The Carbon-based perovskite solar cells (CPSCs) hold the promise of revolutionizing solar energy technology by offering higher efficiency and lower production costs than current alternatives. CPSCs face issues, such as poor infiltration of materials due to uncontrolled porosity and high-temperature processing required in fabrication. This limits the selection of compatible materials and restricts the possibilities for improvements. The use of ink/paste extrusion-based 3D printing techniques are used to overcome these limitations because it enables precise control over porosity during device fabrication. Exploring parametric optimization will allow for successful implementation of this technology, opening up new opportunities for large-scale and cost-effective solar cell production, which drives the transition toward sustainable energy sources. This research also holds significance for the broader field of additive manufacturing, showcasing its potential to revolutionize materials science and renewable energy technology.

Background

Among various renewable energy technologies, solar energy stands out as a promising and abundant source of clean power. Traditional silicon-based solar cells have dominated the market for decades, but carbon-based perovskite solar cells (CPSCs) have garnered significant attention in recent years due to their exceptional potential for higher efficiency and lower production costs compared to traditional silicon solar cells.

The unique electronic and optoelectronic properties of perovskite materials have enabled CPSCs to achieve remarkable power conversion efficiencies, rapidly advancing this technology towards commercial viability. Carbon-based perovskites have emerged as a promising alternative to hybrid perovskite materials, offering improved thermal and chemical stability for long term use.

Despite the remarkable progress, CPSCs face challenges that hinder their widespread commercialization. One crucial limitation is the difficulty in achieving uniform material infiltration during the fabrication process. Uncontrollable porosity in conventional fabrication methods, and high-temperature processing steps results in non-uniform material distribution, and limit compatible materials leading to reduced device performance and reliability. To overcome these limitations and accelerate the development of CPSCs, innovative approaches such as ink-based 3D printing techniques, including inkjet printing and paste extrusion-based 3D printing, have emerged as potential solutions.

These techniques offer precise control over material deposition and porosity during device fabrication, providing a pathway towards large-scale and cost-effective CPSC production.

Figure 1: CPSC Structure

Explorations and Findings

To begin the fabrication of solar cells using the Ink-Based Screen Printer, the initial step involves the careful selection and preparation of materials and ink formulations for ink-based 3D printing of CPSCs (Colloidal Perovskite Solar Cells). This entails choosing appropriate perovskite precursors, additives, and solvents to develop an optimized ink formulation that is suitable for printing CPSCs. To achieve the desired properties of the printed perovskite layer, such as uniformity, stability, and compatibility with different substrates, various ink compositions are evaluated. The optimization process includes exploring a range of perovskite precursor concentrations, solvent ratios, and additives. Once the suitable materials are identified, they are mixed and homogenized using mechanical agitation or ultrasonication to ensure a homogeneous ink solution. Additionally, the ink's viscosity and surface tension are measured to assess its printability and compatibility with the chosen printing method.

three groups collaboratively set up the screen printer and created a design for single or multiple cells. Limitations in testing equipment meant that testing the final product did not occur but looking at how the technology faired in other tests conducted by other laboratories the efficiency yielded was around 18% to 25%, highlighting that for a much faster manufacturing process and a much lower cost the efficiency was not lost. However, there were some challenges in experimentation with the settling of the ink being slightly uneven which would have led to fluctuations during the testing phase. This issue was mainly caused by the ink's viscosity prior to application which led to uneven baking of the material.

Figures 2-4: Researchers Showcasing the Process of Ink Based 3D Printing (from Fan 2023) Ink Development, and the End Product Shown (from left to right, top to bottom)

All Photographs and Figures Were Taken/Created by Researchers

Conclusion

In conclusion, the research on Carbon-based perovskite solar cells and ink-based 3D printing offers promising solutions for the global pursuit of clean and sustainable energy sources. CPSCs, with their high efficiency and low production costs, hold the potential to revolutionize solar energy technology and drive the transition towards renewable energy systems. The use of ink-based 3D printing to overcome fabrication challenges showcases the transformative power of additive manufacturing in materials science and renewable energy technology.

This research contributes to the advancement of sustainable energy solutions by exploring innovative approaches to solar cell fabrication and highlighting the potential of CPSCs in various applications. The findings underscore the importance of ongoing research to enhance CPSC stability, improve interface engineering, optimize manufacturing processes, and explore tandem solar cells and other advanced architectures.

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Acknowledgements

Thank you to NYU Tandon School of Engineering, New York City College of Technology, and Indian Institute of Technology at Mandi for planning, hosting, and supporting this research project. Thank you to The National Science Foundation (NSF) and International Research Experience for Students (IRES) summer program for funding this research, as well as to the graduate students and professors who assisted and guided this project by providing materials and knowledge.

CYBERSECURITY

IRES FEASIBILITY INVESTIGATION OF 3D PRINTABLE BIO-POLYMER

Bio-polymers are theorized as a sustainable alternative to 3D printing materials using plant-based oils as a base. Among the available renewable material systems like polysaccharides and proteins, plant-based oils have emerged as a promising candidate due to their inherent properties and abundance. Vat Polymerization techniques, such as stereolithography and digital light processing, are the most affected through this research. These polymers can be synthesized utilizing the abundant local fauna, which opens new renewable sources of engineering materials while minimizing impact on the environment. This approach will enable the production of wearable sensors with enhanced functionalities and foster advancements in functional tissue applications. Furthermore, the implications of this research extend beyond the biomedical field and could revolutionize industries that strive toward the use of biodegradable and eco-friendly materials. Additionally, leveraging bio-polymers in 3D printing can reduce waste and energy consumption, making it a crucial step toward a more sustainable future.

Project Supervisor: Nikhil Gupta (MAE); **Faculty Mentors:** Akm Samsur Rahman, Mrityunjay Doddamani; **Research Staff:** Caleb Beckwith; **Other Collaborators:** Deepak Sharma, Uthamkumar

Research Area: *Cybersecurity*



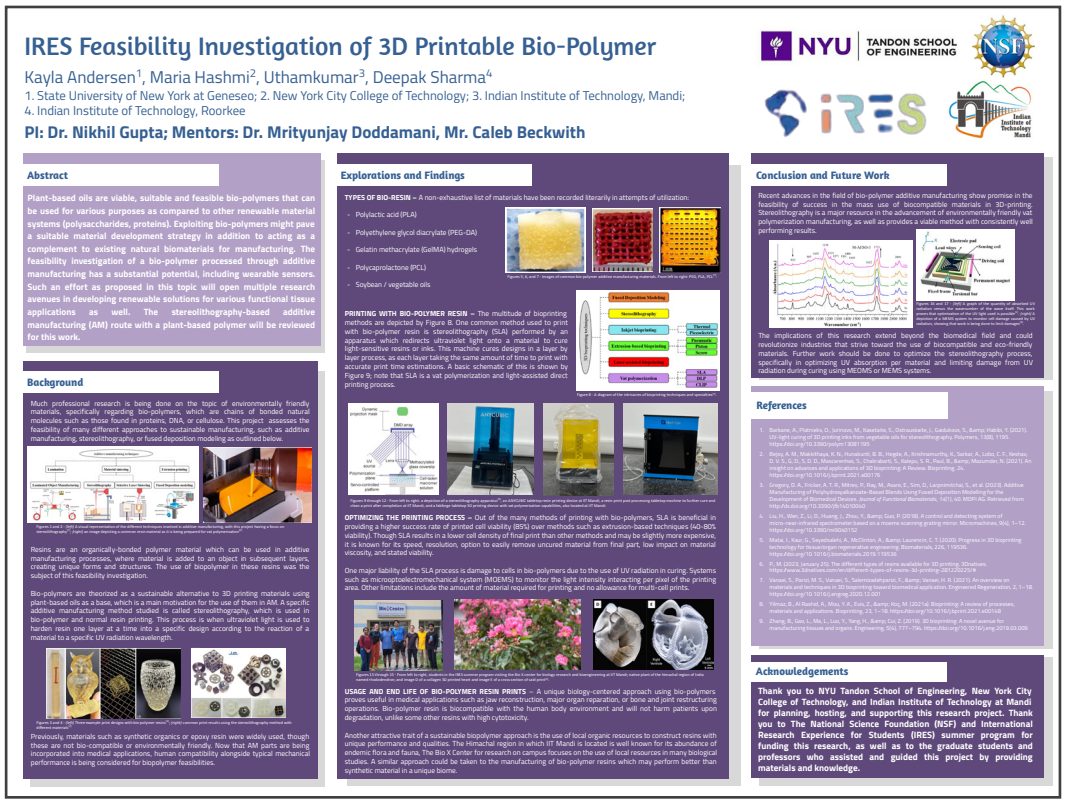
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IRES Feasibility Investigation of 3D Printable Bio-Polymer

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Abstract

Plant-based oils are viable, suitable and feasible bio-polymers that can be used for various purposes as compared to other renewable material systems (polysaccharides, proteins). Exploiting bio-polymers might pave a suitable material development strategy in addition to acting as a complement to existing natural biomaterials for manufacturing. The feasibility investigation of a bio-polymer processed through additive manufacturing has a substantial potential, including wearable sensors. Such an effort as proposed in this topic will open multiple research avenues in developing renewable solutions for various functional tissue applications as well. The stereolithography-based additive manufacturing (AM) route with a plant-based polymer will be reviewed for this work.

Background

Much professional research is being done on the topic of environmentally friendly materials, specifically regarding bio-polymers, which are chains of bonded natural molecules such as those found in proteins, DNA, or cellulose. This project assesses the feasibility of many different approaches to sustainable manufacturing, such as additive manufacturing, stereolithography, or fused deposition modeling as outlined below.

Resins are an organically-bonded polymer material which can be used in additive manufacturing processes, where material is added to an object in subsequent layers, creating unique forms and structures. The use of biopolymer in these resins was the subject of this feasibility investigation.

Bio-polymers are theorized as a sustainable alternative to 3D printing materials using plant-based oils as a base, which is a main motivation for the use of them in AM. A specific additive manufacturing method studied is called stereolithography, which is used in bio-polymer and normal resin printing. This process is when ultraviolet light is used to harden resin one layer at a time into a specific design according to the reaction of a material to a specific UV radiation wavelength.

Previously, materials such as synthetic organics or epoxy resin were widely used, though these are not bio-compatible or environmentally friendly. Now that AM parts are being incorporated into medical applications, human compatibility alongside typical mechanical performance is being considered for biopolymer feasibilities.

Explorations and Findings

TYPES OF BIO-RESIN – A non-exhaustive list of materials have been recorded literarily in attempts of utilization:

- Polylactic acid (PLA)
- Polyethylene glycol diacrylate (PEG-DA)
- Gelatin methacrylate (GelMA) hydrogels
- Polycaprolactone (PCL)
- Soybean / vegetable oils

PRINTING WITH BIO-POLYMER RESIN – The multitude of bioprinting methods are depicted by Figure B. One common method used to print with bio-polymer resin is stereolithography (SLA) performed by an apparatus which redirects ultraviolet light onto a material to cure light-sensitive resins or inks. This machine cures designs in a layer by layer process, as each layer taking the same amount of time to print with accurate print time estimations. A basic schematic of this is shown by Figure 9; note that SLA is a vat polymerization and light-assisted direct printing process.

OPTIMIZING THE PRINTING PROCESS – Out of the many methods of printing with bio-polymers, SLA is beneficial in providing a higher success rate of printed cell viability (85%) over methods such as extrusion-based techniques (40-80% viability). Though SLA results in a lower cell density of final print than other methods and may be slightly more expensive, it is known for its speed, resolution, option to easily remove uncured material from final part, low impact on material viscosity, and stated viability.

One major liability of the SLA process is damage to cells in bio-polymers due to the use of UV radiation in curing. Systems such as microoptoelectromechanical system (MOEMS) to monitor the light intensity interacting per pixel of the printing area. Other limitations include the amount of material required for printing and no allowance for multi-cell prints.

USAGE AND END LIFE OF BIO-POLYMER RESIN PRINTS – A unique biology-centered approach using bio-polymers proves useful in medical applications such as jaw reconstruction, major organ reparation, or bone and joint restructuring operations. Bio-polymer resin is biocompatible with the human body environment and will not harm patients upon degradation, unlike some other resins with high cytotoxicity.

Another attractive trait of a sustainable biopolymer approach is the use of local organic resources to construct resins with unique performance and qualities. The Himachal region in which IIT Mandi is located is well known for its abundance of endemic flora and fauna. The Bio X Center for research on campus focuses on the use of local resources in many biological studies. A similar approach could be taken to the manufacturing of bio-polymer resins which may perform better than synthetic material in a unique biome.

Conclusion and Future Work

Recent advances in the field of bio-polymer additive manufacturing show promise in the feasibility of success in the mass use of biocompatible materials in 3D-printing. Stereolithography is a major resource in the advancement of environmentally friendly vat polymerization manufacturing, as well as provides a viable method with consistently well performing results.

The implications of this research extend beyond the biomedical field and could revolutionize industries that strive toward the use of biocompatible and eco-friendly materials. Further work should be done to optimize the stereolithography process, specifically in optimizing UV absorption per material and limiting damage from UV radiation during curing using MEOMS or MEMS systems.

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Acknowledgements

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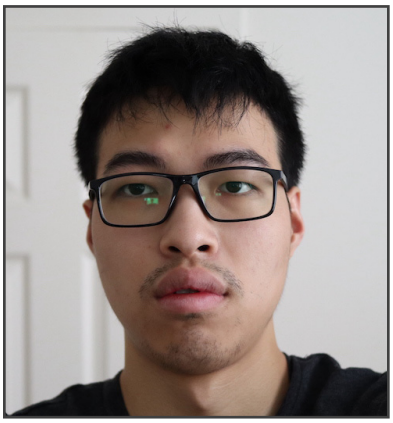
CYBERSECURITY

IRES: PROPERTY PREDICTIONS OF THE ADDITIVELY MANUFACTURED COMPOSITES USING THE MACHINE LEARNING APPROACH

Composite materials play a crucial role in weight-sensitive applications due to their exceptional mechanical properties. However, predicting the mechanical behavior of 3D-printed composites remains challenging due to their myriad processing parameters during manufacturing. To address this challenge, this research focuses on incorporating machine learning (ML) algorithms into the prediction of mechanical properties for 3D-printed composites. By leveraging historical data on materials and printing parameters, ML algorithms can be trained to accurately predict the mechanical properties of new composite structures. Ensemble and automated ML techniques offer predictive capabilities, enabling engineers to optimize composite materials without the need for extensive experimental trials. Automating the iterative tasks involved in developing ML models makes the prediction process more efficient and accessible. By demonstrating the potential of machine learning in predicting material properties, the study contributes to the growing integration of AI and ML in various engineering and manufacturing fields. This research enables the creation of a data-driven manufacturing process that helps drive the product development process in multiple industries.

Project Supervisor: Nikhil Gupta (MAE); **Faculty Mentors:** Akm Samsur Rahman, Mrityunjay Doddamani; **Research Staff:** Caleb Beckwith; Other Collaborators: Krisha Shah, Bhanushri Chinta

Research Area: *Cybersecurity*

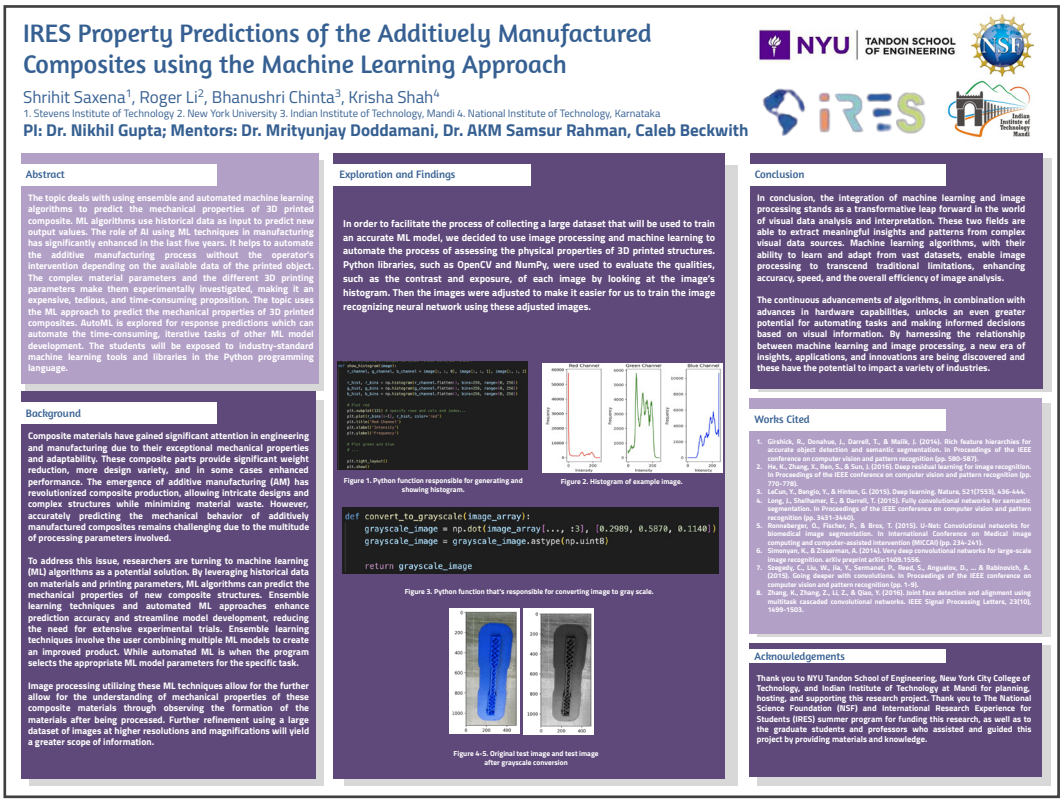


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IRES Property Predictions of the Additively Manufactured Composites using the Machine Learning Approach

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PI: Dr. Nikhil Gupta; Mentors: Dr. Mrityunjay Doddamani, Dr. AKM Samsur Rahman, Caleb Beckwith

NYU TANDON SCHOOL OF ENGINEERING

Abstract

The topic deals with using ensemble and automated machine learning algorithms to predict the mechanical properties of 3D printed composite. ML algorithms use historical data as input to predict new output values. The role of AI using ML techniques in manufacturing has significantly enhanced in the last five years. It helps to automate the additive manufacturing process without the operator's intervention depending on the available data of the printed object. The complex material parameters and the different 3D printing parameters make them experimentally investigated, making it an expensive, tedious, and time-consuming proposition. The topic uses the ML approach to predict the mechanical properties of 3D printed composites. AutoML is explored for response predictions which can automate the time-consuming, iterative tasks of other ML model development. The students will be exposed to industry-standard machine learning tools and libraries in the Python programming language.

Background

Composite materials have gained significant attention in engineering and manufacturing due to their exceptional mechanical properties and adaptability. These composite parts provide significant weight reduction, more design variety, and in some cases enhanced performance. The emergence of additive manufacturing (AM) has revolutionized composite production, allowing intricate designs and complex structures while minimizing material waste. However, accurately predicting the mechanical behavior of additively manufactured composites remains challenging due to the multitude of processing parameters involved.

To address this issue, researchers are turning to machine learning (ML) algorithms as a potential solution. By leveraging historical data on materials and printing parameters, ML algorithms can predict the mechanical properties of new composite structures. Ensemble learning techniques and automated ML approaches enhance prediction accuracy and streamline model development, reducing the need for extensive experimental trials. Ensemble learning techniques involve the user combining multiple ML models to create an improved product. While automated ML is when the program selects the appropriate ML model parameters for the specific task.

Image processing utilizing these ML techniques allow for the further allow for the understanding of mechanical properties of these composite materials through observing the formation of the materials after being processed. Further refinement using a large dataset of images at higher resolutions and magnifications will yield a greater scope of information.

Exploration and Findings

In order to facilitate the process of collecting a large dataset that will be used to train an accurate ML model, we decided to use image processing and machine learning to automate the process of assessing the physical properties of 3D printed structures. Python libraries, such as OpenCV and NumPy, were used to evaluate the qualities, such as the contrast and exposure, of each image by looking at the image's histogram. Then the images were adjusted to make it easier for us to train the image recognizing neural network using these adjusted images.

Figure 1. Python function responsible for generating and showing histogram.

Figure 2. Histogram of example image.

```
def convert_to_grayscale(image_array):
    grayscale_image = np.dot(image_array[..., :3], [0.2989, 0.5870, 0.1140])
    grayscale_image = grayscale_image.astype(np.uint8)

    return grayscale_image
```

Figure 3. Python function that's responsible for converting image to gray scale.

Figure 4-5. Original test image and test image after grayscale conversion

Conclusion

In conclusion, the integration of machine learning and image processing stands as a transformative leap forward in the world of visual data analysis and interpretation. These two fields are able to extract meaningful insights and patterns from complex visual data sources. Machine learning algorithms, with their ability to learn and adapt from vast datasets, enable image processing to transcend traditional limitations, enhancing accuracy, speed, and the overall efficiency of image analysis.

The continuous advancements of algorithms, in combination with advances in hardware capabilities, unlocks an even greater potential for automating tasks and making informed decisions based on visual information. By harnessing the relationship between machine learning and image processing, a new era of insights, applications, and innovations are being discovered and these have the potential to impact a variety of industries.

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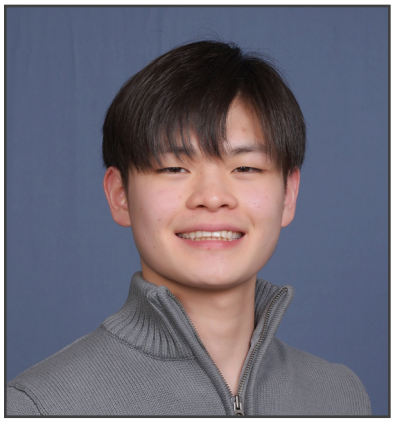
Thank you to NYU Tandon School of Engineering, New York City College of Technology, and Indian Institute of Technology at Mandi for planning, hosting, and supporting this research project. Thank you to The National Science Foundation (NSF) and International Research Experience for Students (IRES) summer program for funding this research, as well as to the graduate students and professors who assisted and guided this project by providing materials and knowledge.

LIND

Lind is a single-process sandbox that can safely execute programs. A new library operating system created with Rust (RUSTPOSIX) runs in Google Native Client (NaCl), a runtime system that performs software fault isolation (SFI), to provide a lightweight cloud environment for the x86 architecture. Lind executes programs while limiting access to the operating system kernel where bugs may live. Running untrusted applications is possible using Lind without making modifications to the kernel while securing legacy program's access to commonly used system functionality such as sockets and file I/O and providing spatial isolation, performance optimization, and portability. For operating system access, Lind provides a subset of POSIX API that is constructed in Rust for performance optimization and memory safety.

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Research Area: *Cybersecurity*



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Lind

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*Work done as a visiting student

Abstract

Lind is a single-process sandbox that can safely execute programs. A new library operating system created with Rust (RUSTPOSIX) runs in Google Native Client (NaCl), a runtime system that performs software fault isolation (SFI), to provide a lightweight cloud environment for the x86 architecture. Lind executes programs while limiting access to the operating system kernel where bugs may live. Running untrusted applications is possible using Lind without making modifications to the kernel while securing legacy program's access to commonly used system functionality such as sockets and file I/O and providing spatial isolation, performance optimization, and portability. For operating system access, Lind provides a subset of POSIX API that is constructed in Rust for performance optimization and memory safety.

Background

Most operating system kernels contain bugs and many efforts fall short of defending against all of them. However, it has been found that locking an application into only using popular OS kernel paths prevents the triggering of kernel bugs [1]. The concept of virtualization has also come up as a way to isolate untrusted code from the operating system kernel [2]. Lind proposes a combination of these two by providing a highly flexible infrastructure that can be integrated with many different applications while locking system calls into the popular paths to maintain security.

Methods and Results

Inside the Linux OS, inter-process communication (IPC) is done through a special type of socket called Unix Domain Sockets (UDS). One main difference between UDS and traditional network sockets is that they only communicate within the local machine, therefore, providing a fast and efficient way to communicate between processes running on the same system. Prior to this summer, the Lind system faked UDS by using network sockets. However, now the Lind system supports IPC through an emulated UDS framework with two FIFOs (pipes). This structure was chosen based on prior results showing that pipes were faster at sending and receiving information than sockets. Ultimately, the Lind system's implementation of UDS is faster than the Linux OS at sending and receiving data.

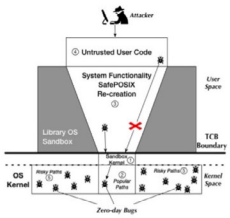


Figure 1: How Lind protects against kernel bugs

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[1] Lock-in-Pop: Securing Privileged Operating System Kernels by Keeping on the Beaten Path
Y. Li, B. Dolan-Gavitt, S. Weber, and J. Cappos
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[2] C. Matthews, J. Cappos, R. McGeer, S. Neville, and Y. Coady,
Workshop on Free Composition (FREECO '11)

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TRACKS: ENHANCING CONTAINER SECURITY WITH LINUX KERNEL HARDENING

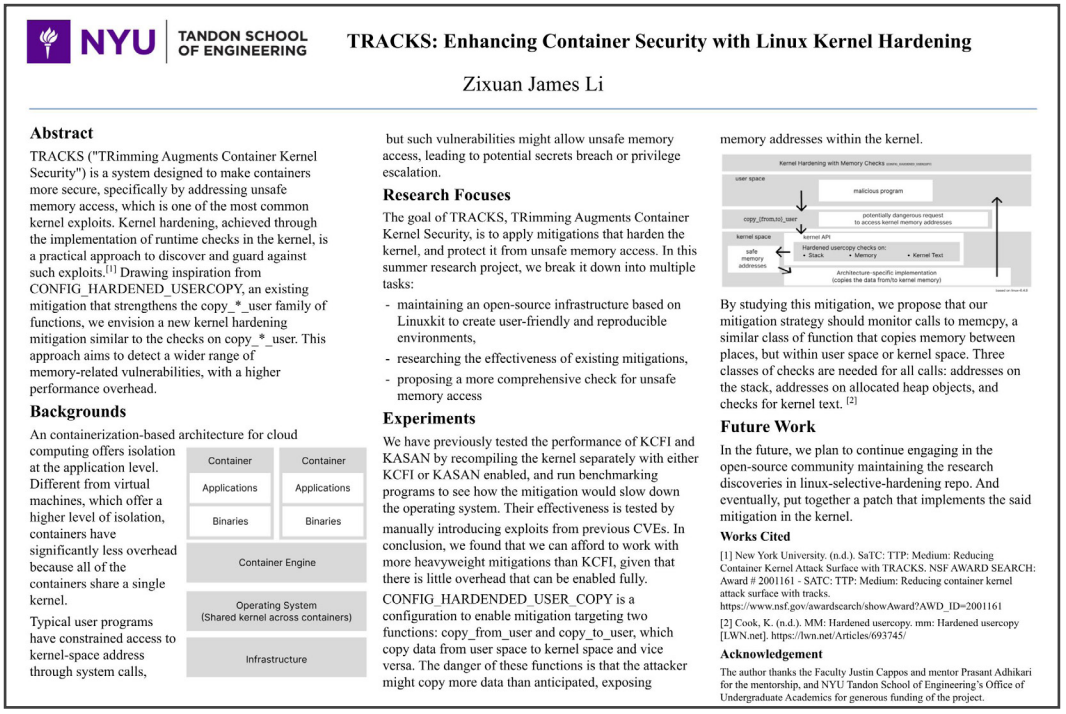
TRACKS ("TRimming Augments Container Kernel Security") is a system designed to make containers more secure, specifically by addressing unsafe memory access, which is one of the most common kernel exploits. Kernel hardening, achieved through the implementation of runtime checks in the kernel, is a practical approach to discover and guard against such exploits. This study focuses on several key tasks: maintaining an open-source infrastructure based on Linuxkit to create user-friendly and reproducible environments, researching the effectiveness of existing mitigations, and proposing a more comprehensive check for out-of-bounds (OOB) memory access. To achieve these goals, the study revisits and updates "linux-selective-hardening", an open-source wrapper of Linuxkit, to benchmark existing mitigations, including KCFI and KASAN. Their effectiveness is tested by manually introducing exploits from previous CVEs. Given the low-performance overhead of KCFI, enabling it by default would not be expensive, so aiming for a higher overhead approach is necessary. Drawing inspiration from CONFIG_HARDENED_USERCOPY, an existing mitigation that strengthens the copy_*_user family of functions, we envision a new kernel hardening mitigation similar to the checks on copy_*_user. This approach aims to detect a wider range of memory-related vulnerabilities, with a higher performance overhead. Looking ahead, future work may involve testing additional mitigations and implementing a Proof of Concept for the proposed hardening technique as a patch.

Project Supervisor: Justin Cappos (CSE); **Faculty Mentor:** Prasant Adhikari

Research Area: *Cybersecurity*



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TRACKS: Enhancing Container Security with Linux Kernel Hardening

Zixuan James Li

Abstract

TRACKS ("TRimming Augments Container Kernel Security") is a system designed to make containers more secure, specifically by addressing unsafe memory access, which is one of the most common kernel exploits. Kernel hardening, achieved through the implementation of runtime checks in the kernel, is a practical approach to discover and guard against such exploits.[1] Drawing inspiration from CONFIG_HARDENED_USERCOPY, an existing mitigation that strengthens the copy_*_user family of functions, we envision a new kernel hardening mitigation similar to the checks on copy_*_user. This approach aims to detect a wider range of memory-related vulnerabilities, with a higher performance overhead.

Backgrounds

An containerization-based architecture for cloud computing offers isolation at the application level. Different from virtual machines, which offer a higher level of isolation, containers have significantly less overhead because all of the containers share a single kernel.

Typical user programs have constrained access to kernel-space address through system calls, but such vulnerabilities might allow unsafe memory access, leading to potential secrets breach or privilege escalation.

Research Focuses

The goal of TRACKS, TRimming Augments Container Kernel Security, is to apply mitigations that harden the kernel, and protect it from unsafe memory access. In this summer research project, we break it down into multiple tasks:

- maintaining an open-source infrastructure based on Linuxkit to create user-friendly and reproducible environments,
- researching the effectiveness of existing mitigations,
- proposing a more comprehensive check for unsafe memory access

Experiments

We have previously tested the performance of KCFI and KASAN by recompiling the kernel separately with either KCFI or KASAN enabled, and run benchmarking programs to see how the mitigation would slow down the operating system. Their effectiveness is tested by manually introducing exploits from previous CVEs. In conclusion, we found that we can afford to work with more heavyweight mitigations than KCFI, given that there is little overhead that can be enabled fully.

CONFIG_HARDENDED_USER_COPY is a configuration to enable mitigation targeting two functions: copy_from_user and copy_to_user, which copy data from user space to kernel space and vice versa. The danger of these functions is that the attacker might copy more data than anticipated, exposing memory addresses within the kernel.

By studying this mitigation, we propose that our mitigation strategy should monitor calls to memcpy, a similar class of function that copies memory between places, but within user space or kernel space. Three classes of checks are needed for all calls: addresses on the stack, addresses on allocated heap objects, and checks for kernel text. [2]

Future Work

In the future, we plan to continue engaging in the open-source community maintaining the research discoveries in linux-selective-hardening repo. And eventually, put together a patch that implements the said mitigation in the kernel.

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The author thanks the Faculty Justin Cappos and mentor Prasant Adhikari for the mentorship, and NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project.

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.

FACULTY

S. Farokh Atashzar (ECE, MAE, BME, CSE)
Joseph Chow (CUE)
Chen Feng (CUE, CSE, MAE, CUSP)
Joo H. Kim (MAE)
Rui Li (GE)
Giuseppe Loianno (ECE, MAE)
Maurizio Porfiri (CUSP, MAE, BME)
Ivan Selesnick (ECE)
Torsten Suel (CSE)
Quanyan Zhu (ECE)



LEARN MORE

ACCESSIBILITY OF HEALTHCARE PROVIDERS ON ONLINE REVIEW SYSTEMS

Online Review Systems (ORSs) are powerful tools that have changed how consumers select products in many different industries. In healthcare, ORSs have improved the accessibility of providers by allowing patients to easily search for physicians in their area and within their insurance network. ORSs also allow patients to view ratings and textual reviews of healthcare providers to ensure they find quality care. While ORSs greatly improve the ease of finding doctors for many people, they also highlight the inequality in the distribution of doctors across the country. We will be analyzing the geographic and socio-economic accessibility of healthcare providers on Online Review Systems. Here we show that there tend to be fewer doctors near regions with high poverty rates and only a small proportion of those doctors are rated well or accept Medicaid, especially in rural areas. We found that poverty rates and the distribution of doctors were negatively spatially correlated across the country at the zip code level. Analyzing urban areas and rural areas separately, we found that there was consistently greater spatial correlation between poverty rates and the distribution of doctors in rural areas. Overall, individuals living in regions with high poverty rates, especially in rural areas, may struggle in trying to find accessible healthcare providers through ORSs.

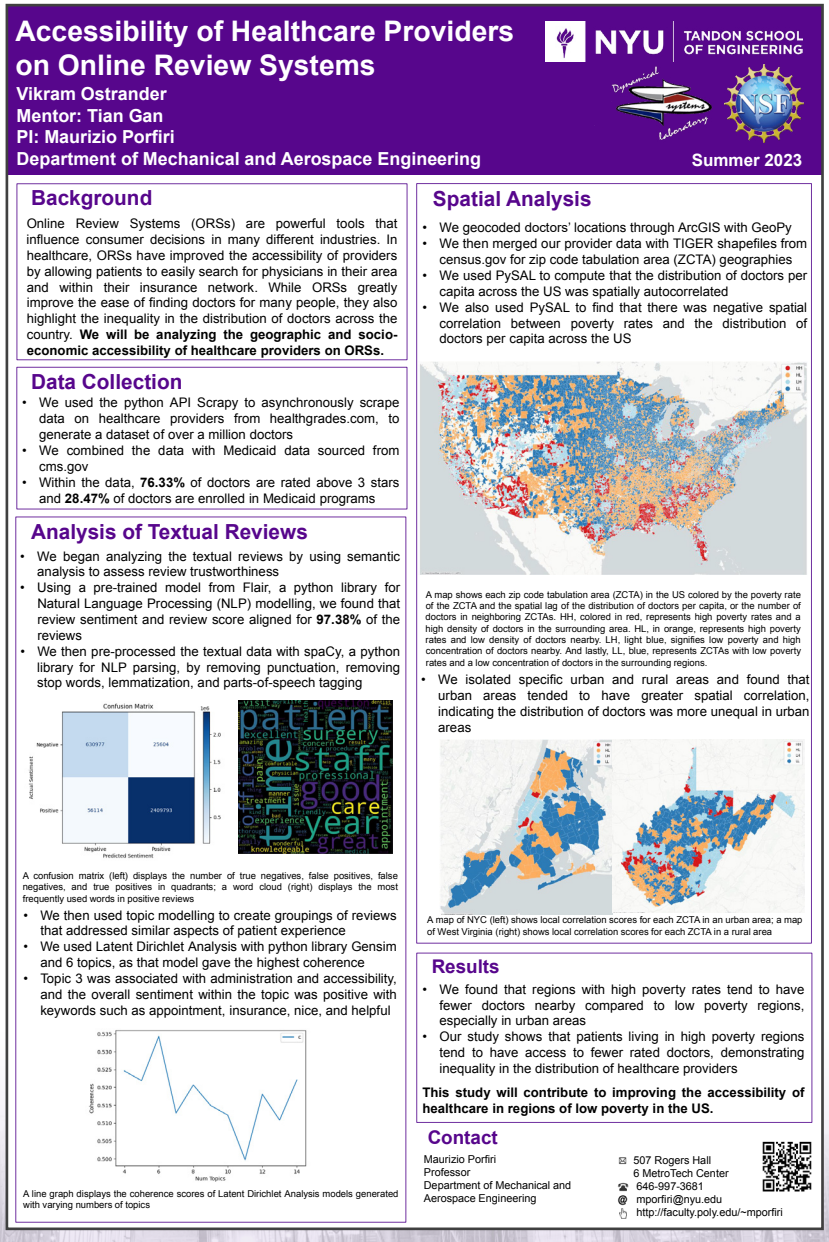
Project Supervisor: Maurizio Porfiri (CUSP, MAE, BME); **Research Staff:** Tian Gan

Research Area: *Data Science/AI/Robotics, Urban*



Vikram Ostrander
Computer Science, B.S., 2025
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Visiting Student Fellow



ACOUSTIC PROPRIOCEPTION IN SOFT-ROBOTICS

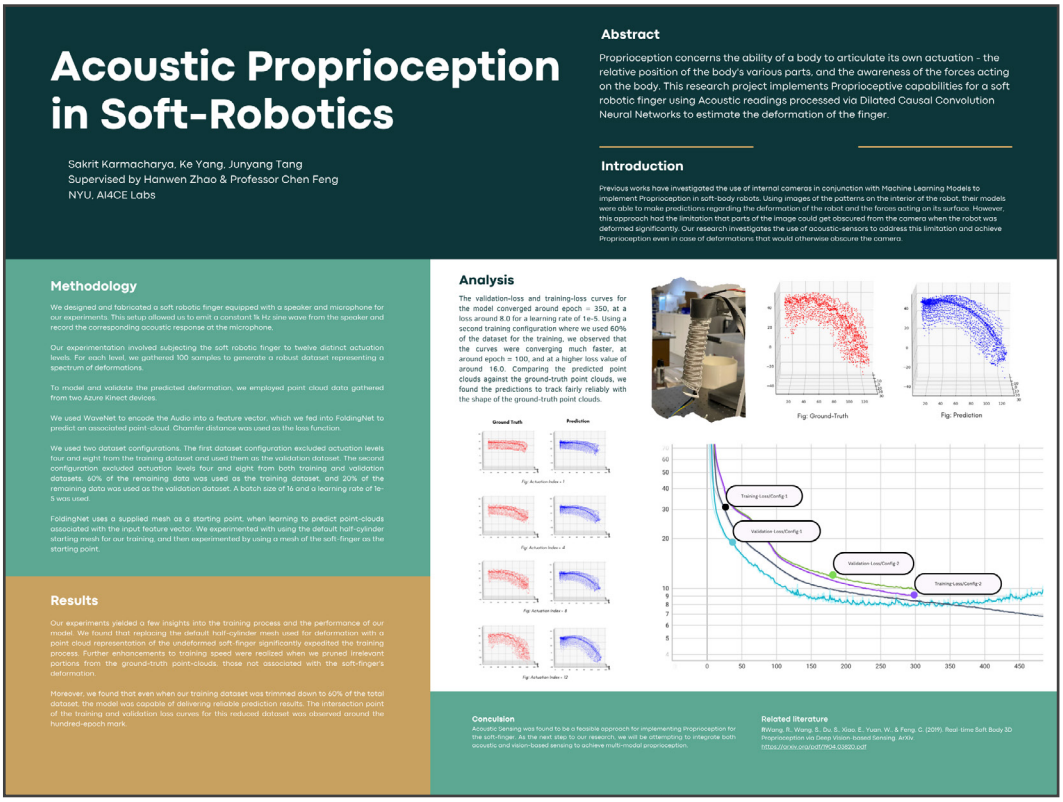
Soft robotics, characterized by their flexible, deformable structures, present a distinct advantage over traditional rigid-body robots. Their softer composition promotes safer interactions with humans and delicate objects, as they are capable of manipulating irregularly shaped objects with less risk of damage and accessing spaces rigid robots cannot. However, the incorporation of electronic and mechanical components, specifically those facilitating proprioceptive sensing, poses a substantial challenge as it risks compromising the robot's inherent flexibility and deformability. Proprioception enables the robot to discern the magnitude and location of the forces on its surface, along with the resulting deformations. Prior research has utilized internal cameras to capture deformation patterns, utilizing machine learning models to correlate these images with predictions of robot deformation and forces. Yet, significant deformations may obscure parts of the internal surface from the camera, inhibiting prediction accuracy. This research project proposes an augmentation of vision-based proprioception with acoustic proprioception in soft robotics. By producing a predetermined frequency sound within a soft robotic finger and analyzing how the finger's deformation modifies this sound using Dilated Causal Convolution Neural Networks, we aim to enhance proprioceptive capabilities, ensuring accurate, reliable functionality in various operational scenarios.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Hanwen Zhao

Research Area: *Data Science/AI/Robotics*



Sakrit Karmacharya
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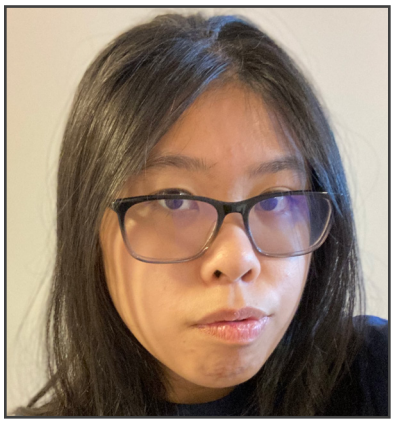


BIO-INSPIRED SOFT ROBOT WORM

Biomimetic robots have made significant progress in locomotion, however difficult terrain proves challenging for most limbed robots with a host of issues such as balance and slippage. Earthworms and other soft invertebrates move with a type of limbless locomotion that can easily navigate such environments. The peristaltic locomotion that such creatures perform uses systematic contraction and expansion radially and longitudinally to propel itself through intricate surfaces instead. This project designs a robotic system that imitates this peristaltic locomotion using a series of modular segments composed of soft components that are activated by servo motors. To move through difficult terrain the robot has high durability and flexibility. The developed robot is able to navigate through complex environments, to detect and avoid obstacles accordingly, and to move consistently throughout operation. In the future, in order to be used in a complex environment, the system could be independently powered and can be controlled wirelessly with on board computer vision.

Project Supervisor: Rui Li (GE); **Other Collaborators:** Antonia Ang

Research Areas: *Data Science/AI/Robotics, Health*



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NYU TANDON SCHOOL OF ENGINEERING

Biomimetic Robotic Worm

Antonia Ang, Megan Chang, Tyler Chen

New York University, Tandon School of Engineering

Abstract

This project designs a robotic system that imitates peristaltic locomotion using a series of modular segments composed of soft components that are activated by servo motors. In order to be used in a complex environment, the system is independently powered and can be controlled wirelessly with on board computer vision. To move through difficult terrain the robot has high durability and flexibility. The developed robot is able to navigate through complex environments, to detect and avoid obstacles accordingly, and to move consistently throughout operation.

Background

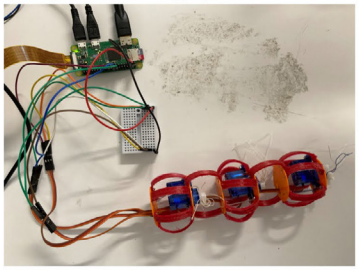
Biomimetic robots take inspiration from nature in order to recreate systems found in animals and plants for alternative usage. In particular, biomimetic robotics have made significant progress in locomotion, however difficult terrain proves challenging for most limbed robots with a host of issues such as balance and slippage. Earthworms and other soft invertebrates move with a type of limbless locomotion, peristaltic locomotion, that can easily navigate such environments. The peristaltic locomotion that such creatures perform uses systematic contraction and expansion radially and longitudinally of circular muscles accordingly [1].

to control the friction along its skin and to propel itself through intricate surfaces instead. Innovative locomotion can aid in travelling terrain for search and rescue purposes. In order to traverse difficult terrain and squeeze past rubble, a robot mimicking the peristaltic locomotion of a worm proves useful [2].

System Architecture

The proposed system includes rigid disks housing servo motors connected by soft TPU brackets. A set of strings is passed through the disks connected to the servo, which actuates the expansion and contraction.

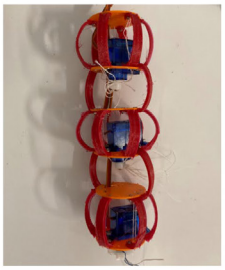
The servos are connected to a Raspberry Pi 0 microcontroller, which can be activated using Bluetooth. An elastic braided mesh and imitation setae needles were optionally attached for testing purposes.



Testing

Python was used to communicate with the microcontroller, actuating all servos in sequence to provide movement. The robot was tested on flat and rocky terrain, achieving ideal movement with an elastic braided mesh on flat surfaces, and with imitation setae on rocky surfaces. The robot successfully achieved movement on flat surfaces.

Figure 2: A Diagram about Layouts



Future Work

Computer vision with wireless integration, independent housing, and smaller micro components can be implemented in the future to further develop an independent system that can be used from a distance.

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Acknowledgement

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

CHAMBOLLE'S ALGORITHM WITH MEDIAN ABSOLUTE DEVIATION

Lasso, which stands for Least Absolute Shrinkage and Selection Operator , is a common regularization technique for variable selection and numerous methods have been developed for solving Lasso in recent years. However, the efficacy of these methods heavily relies on the proper choice of tuning parameters, making it desirable to find an automated approach for tuning parameter selection. One such technique involves using the median absolute deviation(MAD). In this paper, we explored the effectiveness of the "MAD" by incorporating it into Chambolle's algorithm for Total Variation Denoising. Extensive experimentation is conducted to assess the performance of Chambolle's algorithm with MAD under diverse noise scenarios characterized by different sigma levels. It is shown that Chambolle's algorithm with MAD is able to maintain consistent performance as the noise sigma level increases. This result revealed that Chambolle's algorithm with MAD exhibited stronger robustness against data outliers.

Project Supervisor: Ivan Selesnick (ECE)

Research Area: *Data Science/AI/Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Adaptive regularization parameter tuning algorithm for ridge regression in the context of nonstationary data streams

Shengyao(Alex) Tang

Abstract

The choice of regularization parameter in the context of lasso and ridge regression has significant impact on the performance of the algorithm. A lot of parameter tuning criterion have been developed for stationary data. In this paper, we consider the case in which the data is streaming and the underlying distribution of the data is continuously changing. Our approach employs stochastic gradient descent to update the regularization parameter. While more experiments are still required to evaluate the performance of our new algorithms. Related work revealed that our approach has the potential to outperform other popular parameter tuning criterion available.

Background & Problem Setup

In this work, we are interested in tuning a regularization parameter which would gives ridge regression the highest prediction accuracy in the context of nonstationary data streams. Mathematically, we are interested in minimizing the cost function (Figure 1).

The cost function is composed of two terms. The first term is the data fidelity term and the second term is the regularization term. The data fidelity term controls the degree of accuracy for the data, while the regularization parameter prevents the data from over-fitting by shrinking data toward the zero. The parameter we are interested in is $\boldsymbol{\lambda}$ (lambda). This parameter controls the balance between accuracy and shrinkage.

Other parameters and coefficients in our cost function are $\boldsymbol{w}$ (weights indicating the importance give to past observations)[1], $\boldsymbol{y}$ (the observation), $\mathbf{X}$(the predictor), and $\boldsymbol{\beta}$ (the regression parameters).

Figure 1: Cost Function for Ridge Regression

$$L_t(\beta_t, \lambda_t) = \sum_{i=1}^{t} w_i (y_i - X_i^T \beta)^2 + \lambda \|\beta\|_2^2$$

w_i : *weights indicating the importance given to past observations,*

y_i : *responses*

X_i : *predictors*

β : *regressionparameters*

Data Simulation & Algorithm

To train and test our algorithm, y, the observation data, and $\mathbf{X}$, the predictor, are simulated. Specifically, whereas $\mathbf{X}$ is a matrix representation of a multivariate Gaussian distribution[2]. Having generated $\mathbf{X}$, a sparse vector of regression coefficients $\boldsymbol{\beta}$ is generated randomly according to a Gaussian distribution. With $\mathbf{X}$ and $\boldsymbol{\beta}$ generated, we sample $\boldsymbol{y}$ from a normal distribution with a mean at zero and a covariance of $\mathbf{X}'\boldsymbol{\beta}$.

The algorithm we used to is referred to as Real-time Adaptive Penalization (RAP). At each iteration a new pair of data $\mathbf{X}$ and $\boldsymbol{y}$ are generated according to the procedure mentioned above , while $\boldsymbol{\lambda}$ is initialized by sampling from a union distribution and is updated through a stochastic gradient descent framework as shown in the Figure 2. Here, $\mathbf{C}$ is the residual error on the unseen data. Eventually, give the $\boldsymbol{\lambda}$ at each iteration, we update the regression coefficient $\boldsymbol{\beta}$ by minimizng the ridge regression.

Figure 2: Real-time Adaptive Penalization Framework

$$\begin{aligned} &For\ each\ iteration, \\ &1.\ receive\ new\ (X_t, y_t) \\ &2.\ \lambda_(t+1) \ = \ \lambda_t - \epsilon \frac{\partial C_(t+1)}{\partial \lambda_t} \\ &3.\ \beta_(t+1) = argmin\ L_(t+1)(\beta, \lambda_(t+1)) \\ &\\ &Whereas, \\ &C = C(X, y) = \left\| y - X^T \beta \right\|_2^2 \end{aligned}$$

Result

We still need more experiments to determine the effectiveness of the new proposed algorithm. However, based on a related work that applies the similar method on lasso regression. We believe that our work should produce similar positive results.

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CROWD MONITORING: AN ENERGY-AWARE METHOD

Multi-object detection and crowd counting are crucial for many applications, such as urban surveillance monitoring and prediction, and are often more desirable through easy-to-deploy but power-constrained devices, due to the unavailability or high cost of power and hardware investment. As a result, real-world scenarios often remain underserved by these resource-demanding AI techniques. We propose a novel machine-learning model capable of operating within constrained computational and energy budgets, specifically targeting attachable battery-powered edge devices equipped with RGB cameras. Our model comprises two modules: efficient object counting backbone and strategic adaptive sampling. We first build up the pipeline for online surveillance video preparation and database construction. Experiments with the collected data show that ViT (Vision Transformer, a state-of-the-art technique that has shown promising results in various computer vision tasks) has the potential to reduce computation burden and reinforcement learning can leverage temporal dependency to generate desired sampling policy. By utilizing these strategies, we aim to create a machine-learning framework that delivers respectable performance on edge devices while minimizing resource requirements.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Ruixuan Zhang

Research Areas: *Data Science/AI/Robotics, Urban, Sustainability*



Kecen (Kevin) Yao
Computer Science, B.S., 2024
NYU Shanghai

NYU TANDON SCHOOL OF ENGINEERING

Energy-aware Multi-object Active Monitoring

Kecen Yao[1]
Supervised by: Ruixuan Zhang,[2] Chen Feng[2]
1. New York University Shanghai 2. AI4CE Lab, New York University

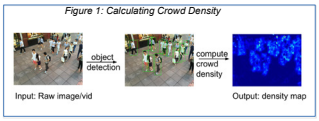
Abstract

Multi-object detection and crowd counting are crucial for many applications, such as urban surveillance monitoring and prediction, and are often more desirable through easy-to-deploy but power-constrained devices, due to the unavailability or high cost of power and hardware investment. As a result, real-world scenarios often remain underserved by these resource-demanding AI techniques. We propose an novel machine-learning model capable of operating within constrained computational and energy budgets, specifically targeting attachable battery-powered edge devices equipped with RGB cameras. Our model comprises two modules: efficient object counting backbone and strategic adaptive sampling. We firstly build up the pipeline for online surviencline videos preparation and database construction. Experiments with the collected data show that ViT (Vision Transformer) has the potential to reduce computation burden and reinfocement learning can leverage temporal dependency to generate desired sampling policy.

Introduction

Crowd density in computer vision refers to measuring or estimating the number of individuals present in a specific area within an image or video frame. Crowd density estimation helps in understanding how densely populated an area is, which can assist in making informed decisions and taking appropriate actions. We will evaluate crowd density through a density map in this research. A density map is generated for the image, where each pixel represents the crowd density at that particular location. These methods take into account the spatial distribution of people and provide a continuous estimation of crowd density. A density map can be created by applying a Gaussian filter to the bounding box detected by object detection models, we use huggyface visual transformer in this case. See Figure 1 for reference. Crowd density estimation has applications in a wide range of fields, including crowd management at public events, monitoring pedestrian traffic flow in urban areas, ensuring safety in crowded spaces, optimizing public transportation, and more.

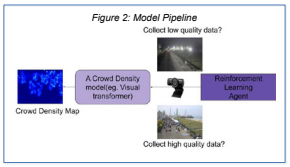
Figure 1: Calculating Crowd Density



Methodology

Our approach involves novel techniques for crowd detection from video data, representation learning to enable efficient training and inference, and the design of sensor activation policies. To be specific, we have designed a unique model capable of functioning as a low-resolution crowd detection system, and dynamically making decisions through reinforcement learning about when to switch to high-resolution crowd detection when high-quality video is needed for accuracy. This adaptive approach optimizes the utilization of computational resources, allowing the model to be more efficient and responsive to the specific needs of different human detection environments. See Figure 2.

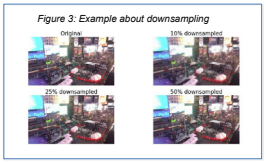
Figure 2: Model Pipeline



Dataset Construction

In order to obtain the data that can be used to train the model, we developed a tool by python that can download online streaming videos, such as from Youtube and EarthCam, for any length. It is also able to downsample the video downloaded to any resolution, figure 3 is an example of its functionality.

Figure 3: Example about downsampling



Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for holding the 2023 UGSRP.

COMPETITIVE REINFORCEMENT LEARNING AS A SEQUENCE MODELING PROBLEM

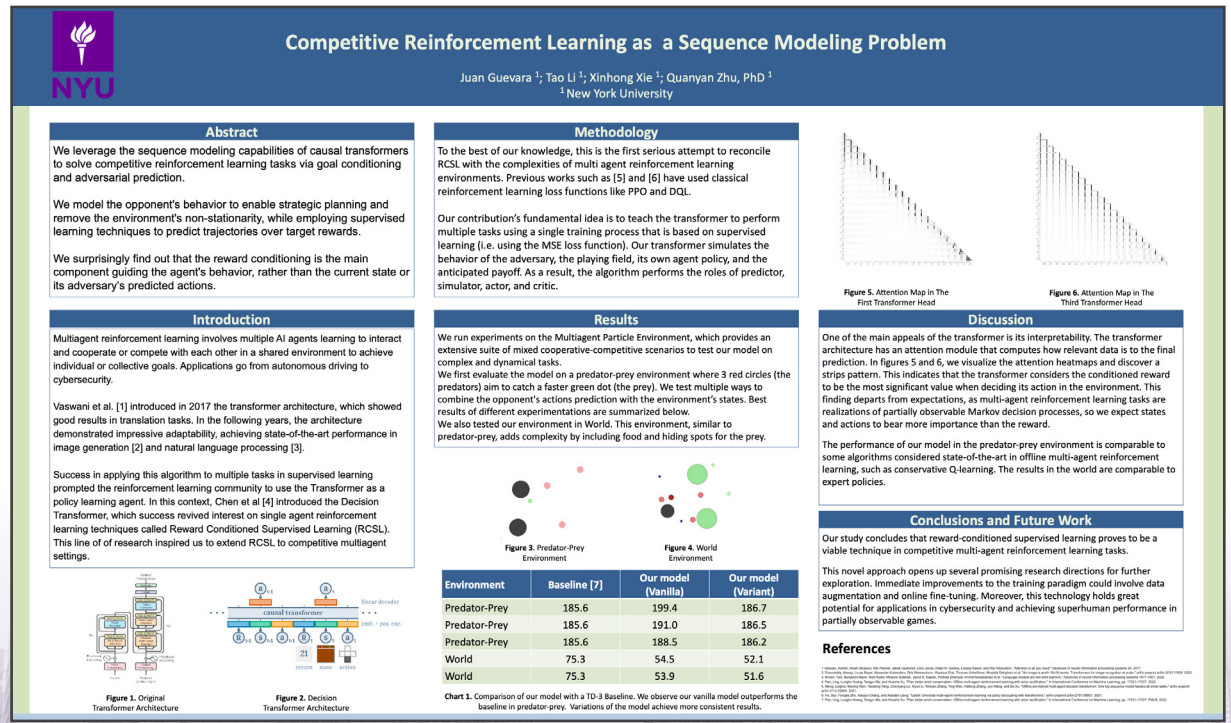
We leverage the sequence modeling capabilities of causal transformers to solve competitive reinforcement learning tasks via goal conditioning and adversarial prediction. Unlike previous attempts to apply transformers in multiagent settings, we deviate from cooperative-only environments, and do not rely on classical RL functions such as the Proximal Policy Optimization or Time Difference loss, but on the rather simple conditioning of the trajectory over a target reward. Additionally, we use the transformer to anticipate the opponent's behavior to enable strategic planning and remove the environment's non-stationarity. We investigate how accurate and relevant these predictions are for determining the agent's next action. We run experiments on the Multiagent Particle Environment, which provides an extensive suite of mixed cooperative-competitive scenarios to test our model on complex and dynamical tasks. We surprisingly find out that the reward conditioning is the main component guiding the agent's behavior, rather than the current state or its adversary's predicted action.

Project Supervisor: Quanyan Zhu (ECE); **Other Collaborators:** Xinhong Xie, Tao Li

Research Area: *Data Science/AI/Robotics*



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Competitive Reinforcement Learning as a Sequence Modeling Problem

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[1] New York University

Abstract

We leverage the sequence modeling capabilities of causal transformers to solve competitive reinforcement learning tasks via goal conditioning and adversarial prediction.

We model the opponent's behavior to enable strategic planning and remove the environment's non-stationarity, while employing supervised learning techniques to predict trajectories over target rewards.

We surprisingly find out that the reward conditioning is the main component guiding the agent's behavior, rather than the current state or its adversary's predicted actions.

Introduction

Multiagent reinforcement learning involves multiple AI agents learning to interact and cooperate or compete with each other in a shared environment to achieve individual or collective goals. Applications go from autonomous driving to cybersecurity.

Vaswani et al. [1] introduced in 2017 the transformer architecture, which showed good results in translation tasks. In the following years, the architecture demonstrated impressive adaptability, achieving state-of-the-art performance in image generation [2] and natural language processing [3].

Success in applying this algorithm to multiple tasks in supervised learning prompted the reinforcement learning community to use the Transformer as a policy learning agent. In this context, Chen et al [4] introduced the Decision Transformer, which success revived interest on single agent reinforcement learning techniques called Reward Conditioned Supervised Learning (RCSL). This line of of research inspired us to extend RCSL to competitive multiagent settings.

Methodology

To the best of our knowledge, this is the first serious attempt to reconcile RCSL with the complexities of multi agent reinforcement learning environments. Previous works such as [5] and [6] have used classical reinforcement learning loss functions like PPO and DQL.

Our contribution's fundamental idea is to teach the transformer to perform multiple tasks using a single training process that is based on supervised learning (i.e. using the MSE loss function). Our transformer simulates the behavior of the adversary, the playing field, its own agent policy, and the anticipated payoff. As a result, the algorithm performs the roles of predictor, simulator, actor, and critic.

Results

We run experiments on the Multiagent Particle Environment, which provides an extensive suite of mixed cooperative-competitive scenarios to test our model on complex and dynamical tasks.
We first evaluate the model on a predator-prey environment where 3 red circles (the predators) aim to catch a faster green dot (the prey). We test multiple ways to combine the opponent's actions prediction with the environment's states. Best results of different experimentations are summarized below.
We also tested our environment in World. This environment, similar to predator-prey, adds complexity by including food and hiding spots for the prey.

Figure 3. Predator-Prey Environment

Figure 4. World Environment

Environment	Baseline [7]	Our model (Vanilla)	Our model (Variant)
Predator-Prey	185.6	199.4	186.7
Predator-Prey	185.6	191.0	186.5
Predator-Prey	185.6	188.5	186.2
World	75.3	54.5	52.1
World	75.3	53.9	51.6

Chart 1. Comparison of our model with a TD-3 Baseline. We observe our vanilla model outperforms the baseline in predator-prey. Variations of the model achieve more consistent results.

Figure 5. Attention Map in The First Transformer Head

Figure 6. Attention Map in The Third Transformer Head

Discussion

One of the main appeals of the transformer is its interpretability. The transformer architecture has an attention module that computes how relevant data is to the final prediction. In figures 5 and 6, we visualize the attention heatmaps and discover a strips pattern. This indicates that the transformer considers the conditioned reward to be the most significant value when deciding its action in the environment. This finding departs from expectations, as multi-agent reinforcement learning tasks are realizations of partially observable Markov decision processes, so we expect states and actions to bear more importance than the reward.

The performance of our model in the predator-prey environment is comparable to some algorithms considered state-of-the-art in offline multi-agent reinforcement learning, such as conservative Q-learning. The results in the world are comparable to expert policies.

Conclusions and Future Work

Our study concludes that reward-conditioned supervised learning proves to be a viable technique in competitive multi-agent reinforcement learning tasks.

This novel approach opens up several promising research directions for further exploration. Immediate improvements to the training paradigm could involve data augmentation and online fine-tuning. Moreover, this technology holds great potential for applications in cybersecurity and achieving superhuman performance in partially observable games.

References

Figure 1. Original Transformer Architecture

Figure 2. Decision Transformer Architecture

CONNECTIONS IN CRIME RATES ACROSS NYC NEIGHBORHOODS

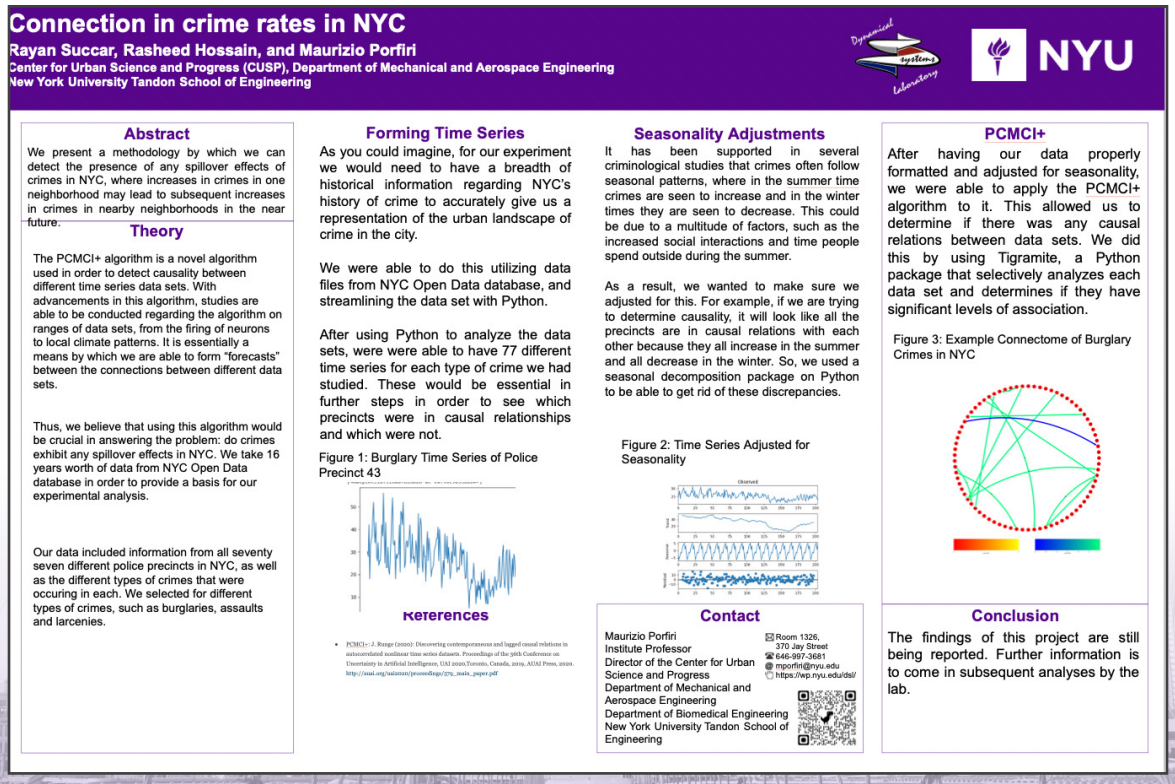
In previous criminological endeavors, researchers have explored the possibility of crime occurrences exhibiting spatiotemporal patterns, which has led to the development of tools for crime prediction. In our current study, we aim to further our understanding of urban criminology by investigating whether crime rates in New York City exhibit any spillover effects. In the field of criminology, spillover effects refer to instances where the presence of crimes in one community serve as a causal factor for the increase in crimes in adjacent communities in the near future; in essence, if two communities are connected via the spillover theory, one would serve as a harbinger for the other in terms of crime occurrences. To do this, we modeled New York City as an interconnected complex network, utilizing over a decade's worth of crime data from the NYPD. The cutting-edge causal discovery algorithm, PCMCI+, was applied to our novel connectome of New York City crimes to unveil any causal structures amongst nearby precincts. Our work promises to be highly valuable in its potential to contribute to the reduction of crime rates and the improvement of public safety in New York City. By advancing our understanding of crime patterns and causal relationships, this research has the power to shape evidence-based policies and practices that foster a safer urban environment for residents and visitors alike.

Project Supervisor: Maurizio Porfiri (CUSP, MAE, BME); **Research Staff:** Rayan Succar

Research Area: *Data Science/AI/Robotics*



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Tandon School of Engineering



DEVELOPING PID CONTROLLER FOR SALTO 1-P JUMPING ROBOT IN MUJOCO

Jumping is a form of locomotion which enables small sized robots to access elevated areas on uneven terrain efficiently where ground-based robots would struggle. This advantage allows jumping robots to be utilized in search and rescue or surveillance missions which require the robot to maneuver in difficult terrain. The use of jumping robots could even be extended to navigate and explore terrain on the Moon where the reduced gravity would enable robots to jump much farther and higher. However, the explosive takeoff of jumping robots on uneven terrain results in landing positions difficult to predict; thus, stability and control of jumping robots midair and during landing is of high importance. For this study, a PID controller was developed in the Mujoco simulation environment to balance the Salto 1-P jumping robot. A PID controller was successfully used to balance an inverted cart pendulum prior to the jumping robot. The PID controller was used on a spring based model of the Salto 1-P jumping robot similar to Mark Raibert's one-legged hopper robot consisting of a hip joint and a springlike prismatic joint.

Project Supervisor: Joo H. Kim (MAE); **Research Staff:** William Z. Peng, Hyunjong Song, Sameer Upadhye, Stacy Ashlyn

Research Areas: *Data Science/AI/Robotics, Urban*



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Visiting Student Fellow

NEW YORK UNIVERSITY

Applied Dynamics & Optimization Lab

Stability Controller for Salto-1P Jumping Robot in Mujoco

Adithya Raman

Mentors: Sameer Upadhye, Faculty Mentor: Professor Joo H. Kim *ADOL, Dept. of Mechanical and Aerospace Engineering, New York University*

ABSTRACT

To stabilize and control jumping robots to land upright and prepare for their next jump, a controller is necessary to actuate the joints of the robot. A PID controller, successfully tested on an inverted cart pendulum, was developed in the Mujoco simulation environment to control the joints of a one-legged spring hopper and a model of the Salto 1-P jumping robot. The controller was used to determine the height of each jump and the foot position before landing.

BACKGROUND

Explosive takeoff of jumping robots on uneven terrain results in landing positions difficult to predict. Thus, stability and control of jumping robots is of high importance in order to perform quick acrobatic maneuvers.

METHODOLOGY

A PID controller was initially developed and tested on an inverted cart pendulum modeled in Mujoco.

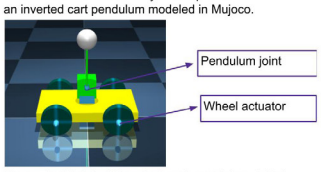


Figure 1: Model of inverted cart pendulum. Total mass is 7 kg.

METHODOLOGY (CONTD.)

The K_p, K_i, and K_d constants were fine tuned to the following values:

- K_p: 30
- K_i: 0.3
- K_d: 15

The control variable was the angular velocity of each of the four wheels; using the left or right arrow keys, a force of 300 Newtons or -300 Newtons, respectively, could be applied on the cart to cause instability. A PD controller was then applied to a one legged spring hopper model and the Salto 1-P jumping robot model. A state machine was used for each of the robots to control the jumping movements.

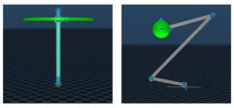


Figure 2 and 3: Model of one legged jumping robot and Salto 1-P.

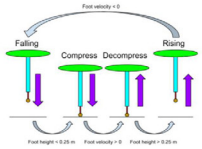


Figure 4: State machine for one legged jumping robot.

METHODOLOGY (CONTD.)

In the one legged jumping robot, the state machines determined the behavior of the spring joint at the leg.

Falling K_p: 100 K_d: 10	Compressing K_p: 1000 K_d: 0
Depressing K_p: 1000 K_d: 0	Rising K_p: 100 K_d: 10

The state machine used on the Salto 1-P robot consisted of the same exact states. Similar to the spring hopper, PD control was used to control the position of the ankle joint and knee joint as to compress the robot, spring the robot, and set it's foot position when falling.

RESULTS AND DISCUSSION

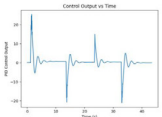


Figure 5: Angular velocity output graph for PID control of inverted pendulum.

The PID output graph demonstrates how the control was effective in getting the inverted pendulum to a stable state. Similarly, the PD control allowed the jumping robots to maintain stability in the air.

FUTURE WORK

- Add flywheel for more control midair and to perform more acrobatic maneuvers.

ACKNOWLEDGMENTS

I thank the NYU Tandon School of Engineering's Office of Undergraduate Academics for their support.

DYNAMIC AWARE SUPERPOINT

The presence of dynamic objects significantly affects the robot's perception of its environment, leading to a decline in performance for crucial tasks like localization and mapping, which is an important concept that enables robots to understand and navigate their environment. There are current implementations of algorithms, such as RANSAC, to filter out dynamic feature points during the mapping process, but they are inefficient. Therefore, the goal of this study is to create a network that not only extracts the feature points, but also classify them pixel-wise into dynamic, semi-dynamic or static. The result of this network will help us inform the nature of objects in the environment, and help disregard the dynamic objects during the feature matching process to increase the localization and map building accuracy. More technically, we combine the results of a semantic segmentation task and optical flow method that uses contextual information separation to produce the required datasets using Kitti datasets and train our model using deep neural networks.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Anbang Yang

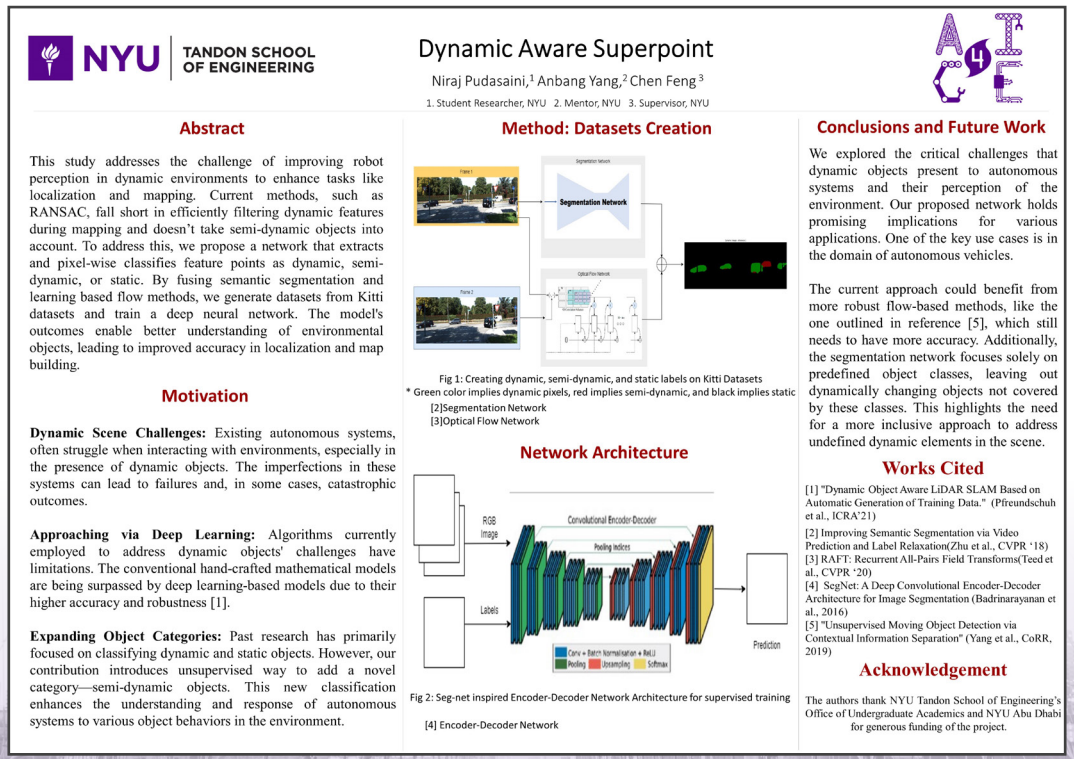
Research Area: *Data Science/AI/Robotics*



Niraj Pudasaini
Electrical Engineering, B.S., 2024
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Optical Flow using RAFT on Kitti Datasets



NYU TANDON SCHOOL OF ENGINEERING

Dynamic Aware Superpoint

Niraj Pudasaini,[1] Anbang Yang,[2] Chen Feng [3]

1. Student Researcher, NYU 2. Mentor, NYU 3. Supervisor, NYU

Abstract

This study addresses the challenge of improving robot perception in dynamic environments to enhance tasks like localization and mapping. Current methods, such as RANSAC, fall short in efficiently filtering dynamic features during mapping and doesn't take semi-dynamic objects into account. To address this, we propose a network that extracts and pixel-wise classifies feature points as dynamic, semi-dynamic, or static. By fusing semantic segmentation and learning based flow methods, we generate datasets from Kitti datasets and train a deep neural network. The model's outcomes enable better understanding of environmental objects, leading to improved accuracy in localization and map building.

Motivation

Dynamic Scene Challenges: Existing autonomous systems, often struggle when interacting with environments, especially in the presence of dynamic objects. The imperfections in these systems can lead to failures and, in some cases, catastrophic outcomes.

Approaching via Deep Learning: Algorithms currently employed to address dynamic objects' challenges have limitations. The conventional hand-crafted mathematical models are being surpassed by deep learning-based models due to their higher accuracy and robustness [1].

Expanding Object Categories: Past research has primarily focused on classifying dynamic and static objects. However, our contribution introduces unsupervised way to add a novel category—semi-dynamic objects. This new classification enhances the understanding and response of autonomous systems to various object behaviors in the environment.

Method: Datasets Creation

Fig 1: Creating dynamic, semi-dynamic, and static labels on Kitti Datasets
* Green color implies dynamic pixels, red implies semi-dynamic, and black implies static
[2]Segmentation Network
[3]Optical Flow Network

Network Architecture

Fig 2: Seg-net inspired Encoder-Decoder Network Architecture for supervised training
[4] Encoder-Decoder Network

Conclusions and Future Work

We explored the critical challenges that dynamic objects present to autonomous systems and their perception of the environment. Our proposed network holds promising implications for various applications. One of the key use cases is in the domain of autonomous vehicles.

The current approach could benefit from more robust flow-based methods, like the one outlined in reference [5], which still needs to have more accuracy. Additionally, the segmentation network focuses solely on predefined object classes, leaving out dynamically changing objects not covered by these classes. This highlights the need for a more inclusive approach to address undefined dynamic elements in the scene.

Works Cited

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[3] RAFT: Recurrent All-Pairs Field Transforms(Teed et al., CVPR '20)
[4] SegNet: A Deep Convolutional Encoder-Decoder Architecture for Image Segmentation (Badrinarayanan et al., 2016)
[5] "Unsupervised Moving Object Detection via Contextual Information Separation" (Yang et al., CoRR, 2019)

Acknowledgement

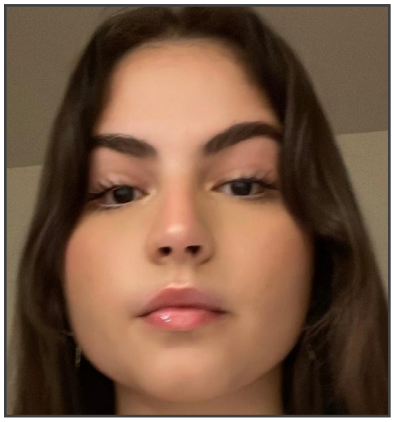
The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics and NYU Abu Dhabi for generous funding of the project.

EXPERIMENTAL INVESTIGATION OF THE SKELETAL ADAPTATIONS OF DEEP SEA SPONGES

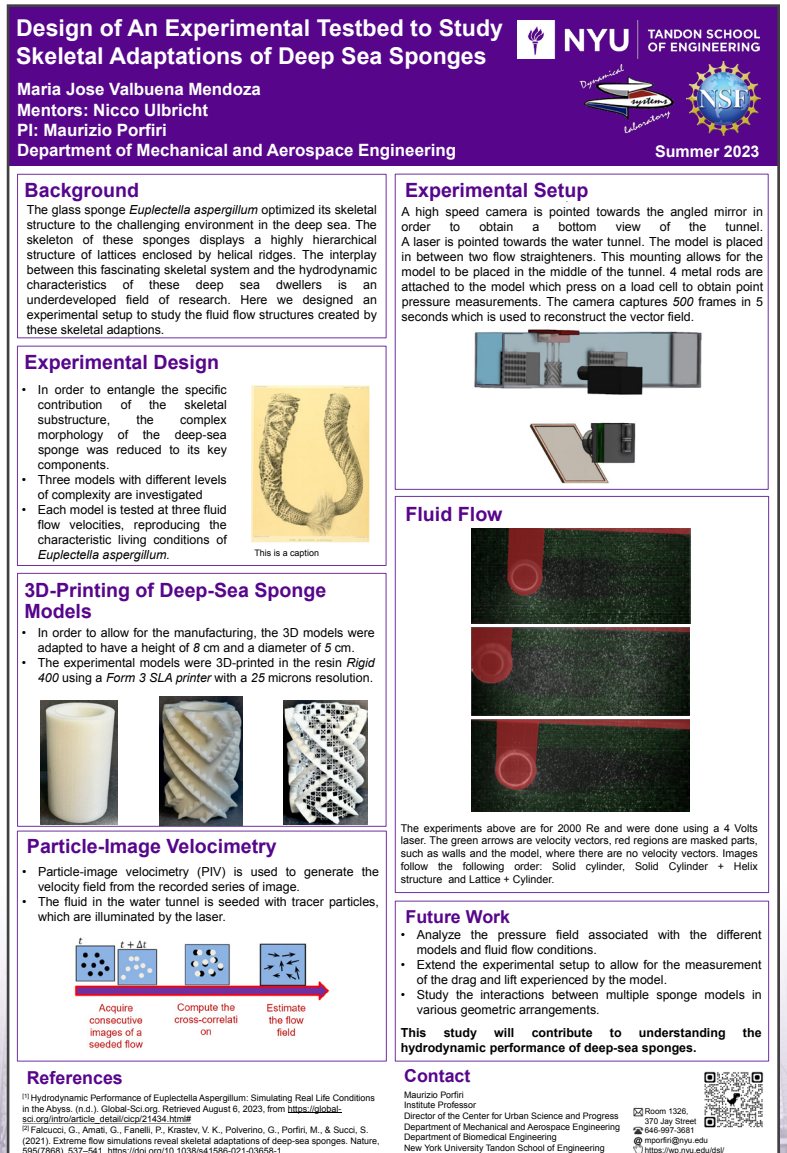
The deep-sea glass sponge Euplectella aspergillum showcases nature's ability to adapt to the most challenging environmental conditions. Under the deep sea living conditions, the glass sponge optimized its structure to provide structural flexibility and mitigate crack propagation. This is achieved by a highly hierarchical structure, consisting of a combination of helical ridges and lattice formations. An underdeveloped domain of research is the hydrodynamic performance of these deep sea dwellers. Previous numerical simulation revealed the sponges ability to reduce its experienced drag and increase the flow residence time within its body cavity. Based on previous numerical simulations, these substructures each played a distinct role in reducing the drag coefficient of the sponge and increasing the flow residence time. In this project, we developed an experimental testbed to look into the hydrodynamic performance of different skeletal adaptations of deep sea sponges. We investigated four 3D printed mock-up models of the sponge. Flow visualization of different characteristic cross-sections were performed using particle-image velocimetry, which constitutes the experimental gold standard of fluid mechanics. To further enrich our findings, pressure field reconstruction and measurements of multi-dimensional drag and lift coefficients are planned. Based on these preliminary results, future efforts will entail the reconstruction of pressure fields and the measurement of mutli-dimensional drag and lift coefficients. Additionally, we aim to explore various geometrical arrangements of multiple sponge models to understand potential collective effects. Our research contributes valuable insights into nature's adaptations and offers inspiration for innovative engineering designs with improved hydrodynamic efficiency.

Project Supervisor: Maurizio Porfiri (CUSP, MAE, BME); **Research Staff:** Nicco Ulbricht

Research Area: *Data Science/AI/Robotics*



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FLEXIBLE STRAIN SENSORS FOR ERGONOMIC BIOLOGICAL SIGNAL MEASUREMENT

A major advent in modern-day robotics is soft-robotics, a subset of robotics focused on flexible, artificial materials that can perform functions modeling living organisms. These give the advantage of performing in soft biological environments where rigid components would normally fail, such as various medical applications or prosthetics. Our work focused on a novel soft-robotics arm system utilizing artificial skin sensors, soft 3D-printed components, pneumatic control systems, and artificial muscles.

When the polyimide film is exposed to a carbon dioxide laser, it has the unique property of transforming into graphite. Laser-engraved sheets were transferred onto the polymer polydimethylsiloxane, which formed a flexible artificial skin. We found that rotation and angle differences caused microfractures between graphite particles, which presented different voltage readings. These can be measured to track movement, touch pressure sensing, and electrical impulses. The sensors will be embedded throughout the soft-robotic arm, providing sensual feedback that will adaptively adjust pressure to ensure proper function.

Pneumatic actuators such as the pneumatic muscles mimic human behavior and mechanics with the benefit of a lightweight design to provide lifting and gripping abilities. The pneumatic fingers have a two-chamber system that allows it to flex at two separate points and adjust their curvature more precisely to solidly grab materials. Fabrication of the artificial muscles are developed using various 3D printers to make soft-flexible shapes that expand and compress from pneumatic inflow. Modeled after natural musculature, they provide smoother extension or compression in a gradual manner that resembles biological systems, preventing sudden, shaky movements.

Project Supervisor: Rui Li (GE)

Research Areas: *Data Science/AI/Robotics, Health*



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Artificial Muscles

Fernando Bedoya Jr,[1] Roland Yan,[1] Antonia Ang,[1]

1. Title and Affiliation 2. Title and Affiliation 3. Title and Affiliation

Abstract

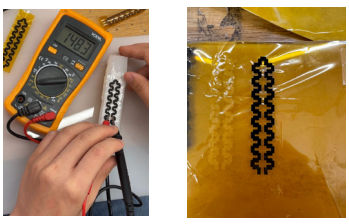
In the field of robotics there is contingency to develop powerful yet cost effective to mimic human movements. Artificial muscles approximate the movements of the biological muscle using pneumatic mechanical techniques to actuate the muscle ideally carrying out an elastic behavior.

Background on the Project

Artificial muscles are designed to produce similar power-to-weight ratio as a human muscle or more. Physical design is created using SolidWorks and then passed onto FormLabs for fabrication. These muscles are 3D printed utilizing soft-elastic materials suited for human interactions. Geometry of the muscle design differ depending on the amount of exertion of power needed when performing a task. A artificial bicep would use a pneumatic system to equate in a pulling force allowing an item to be picked up and recovered from any position. Laser-engraved graphite sheets are transferred onto flexible silicone skin, where its varying voltage resistance from rotation movements, compression, and electrical stimulation can be measured and mapped to track rotation joint movements, touch pressure sensing, and electrical impulses in a very thin, flexible, and robust configuration. These sensors can be embedded throughout the soft-robotic arm, providing sensual feedback that can be used to adaptively adjust pressure to ensure proper function. Their lightweight, thin, and flexible nature make them ideal for environmental sensing.

The process of creating graphite sensors relies on the properties of Kapton film. When the film is exposed to a CO2 laser, it transforms into graphite. After embedding in a silicone layer, stretching or compressing the material will create microfractures between graphite particles, altering the strength of its voltage. These changes can be systematically measured to determine the degree of angle change on various movements.

Figure 1: Laser Engraved Sensors



Test Environment

The sensor is glued onto the prosthetic finger and different voltages are recorded. Data showed the the sensor effectively conducted voltages in the 100-200 volt range, and readings became weaker as the finger had a greater change in angle measurement.

The prototype is controlled using a controls panel on the pump station to control the usage of actuators. The pump station has the ability to pump air or vacuum air. The insertion of air throughout the prototype will result in a curling motion approximately 90 degrees in displacement from its original position resulting in human-like functionality.

Figure 2: Design of Prototype



Future Developments

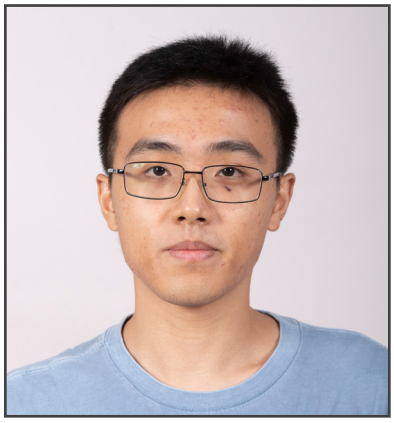
The current prototype focused on lifting a certain payload similar to that of a bicep. Future endeavours include researching into creating different functional muscles that work as a cohesive system to carry out complex movements using earth-friendly materials.

IMPROVING GRAPH-BASED APPROXIMATE NEAREST NEIGHBOR ALGORITHMS

The Approximate Nearest Neighbor problem deals with finding a set of closest points to a given point in a large, high-dimensional data set. The goal is to achieve high accuracy by returning the right points as quickly as possible. This problem is encountered in searching, for example, finding similar images given an input image. To transform this problem into a nearest neighbor problem, the images are converted into a high-dimensional array of numbers, which can be seen as points on a grid. This allows us to compute the distance between the points, a measure of how similar the images are. After running the nearest neighbor algorithm, a set of points representing the images that are the most similar to the input image can be retrieved. Our research focuses on two algorithms, HNSW and Vamana. HNSW and Vamana both involve constructing graphs where points are connected by edges, which are used to navigate between points. HNSW focuses on multiple levels of graphs, where higher levels have fewer points and are used to quickly navigate to a nearby node to begin the nearest neighbor search. Vamana uses a graph that starts with random connections and focuses on improving the connections for quick traversal. Our work is to implement the two algorithms in C++ and to identify the differences between the algorithms, in order to combine them with their advantages.

Project Supervisor: Torsten Suel (CSE); **Research Staff:** Jinrui Gou

Research Area: *Data Science/AI/Robotics*



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Improving Graph-Based Approximate Nearest Neighbor Algorithms

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Abstract

Our project deals with improving existing algorithms proposed for the approximate nearest neighbor problem. The two algorithms are HNSW[1] and Vamana[2]. Both algorithms involve creating connections between points, with the goal of generating a graph whose connections can be utilized to explore only a small subset of points to find a set of nearest neighbors. Our goal is to implement and discover the differences between the two algorithms, with the goal of taking the best features of both algorithms to create a more efficient approach to the approximate nearest neighbor problem.

Background

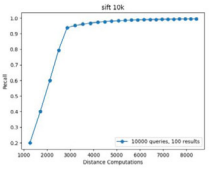
Many algorithms involving searching require a way to compare two objects, for example images or documents. A solution is to convert the objects into a high-dimensional array, whose Euclidean distance represents how similar the objects are to each other. This allows the most similar n objects can be mathematically determined. However, simply computing the distance between an input and every object in the dataset is inefficient, which is where nearest neighbor algorithms come in. The goal of both HNSW and Vamana are to provide both connections to far away objects and nearby objects, with the former being used to quickly navigate to the closest neighbor and the latter used to find the n closest neighbors nearby. Relevant parameters to evaluate performance are the percentage of closest neighbors that are found versus the brute force approach, the time to construct the graph, the average runtime per search.

Method

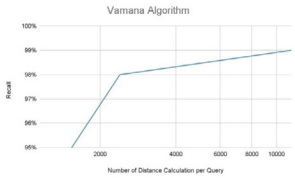
We first implemented the HNSW and Vamana algorithms in C++, while ensuring that the algorithm runs as efficiently as possible without errors. We then evaluated the performance of the algorithm on several datasets using a wide range of parameters to test out the tradeoff between graph construction and percent recall. The results between HNSW and Vamana were compared to determine if there were any significant differences between the recall with similar parameters, which could be used to combine these algorithms together.

Results

The results of both HNSW and Vamana are presented below, for a dataset of 10,000 points and 128 dimensions. The graph depicts distance computations (proportional to runtime) and recall (measure of accuracy of results). 100 queries were ran, with 100 nearest neighbors requested for each query.



Parameters: M = 30, M_max and M_max_0 = 50, Ef_con = 100, Ef_search = 20 to 50 in increments on 20



Parameters: alpha = 1.2, K = 30 (number of NNs when building the graph), R = 50 (maximum outedge), L = L_QUERY = 100 (beam search width)

Discussion

The distance calculations/recall tradeoff can clearly be seen above, with recall increasing rapidly at first, and then tapering off after around 2,500 calculations. The shape of the curves for both algorithms is the same here, indicating that both algorithms behave similarity with this dataset.

Future Work

- Test our implementation on more datasets to observe performance differences between HNSW and Vamana.
- Combine HNSW and Vamana to create a new algorithm that could potentially produce better outcomes.

Acknowledgement

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

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[2] Takami, Sousuke, and Akihiro Inokuchi. "Accurate and Fast Computation of Approximate Graph Edit Distance Based on Graph Relabeling." Proceedings of the 7th International Conference on Pattern Recognition Applications and Methods, 2018, https://doi.org/10.5220/0006540000170026.

IMPROVING LEARNED INDEX STRUCTURES

Traditional search engines have relied heavily on complex textual matching algorithms and frequency-based ranking functions like BM25 for information retrieval. Even though they are computationally efficient, they suffer from the vocabulary mismatch problem where semantically relevant user queries do not syntactically match the keywords indexed for the documents. With the advent of transformers, search engines have started using large language models like BERT to leverage the context of the queries rather than relying solely on syntactic matching. Even though this significantly boosts the accuracy of search results, it comes with a high computational cost. One approach to balance the accuracy and efficiency at the initial stages of reranking is to use neural networks to automatically derive better inverted index structures that approximate transformer-based ranking.

Our research project builds upon DeepImpact (by Mallia et al.) that learns relevance scores for terms in a document by maximizing score difference between relevant and non-relevant passages for given queries. To solve vocabulary mismatch, DeepImpact utilizes an expansion model trained to predict relevant queries for a given passage. In addition, we use a newer approach that filters out non-relevant predicted queries as autoregressive LLMs are prone to hallucination. We also fine-tune more recent BART and LLaMa 2 models for expansion instead of using T5. Our results show improvements in Mean Reciprocal Ratio (MRR@10) although Recall remains the same. Furthermore, we explore a novel approach of analyzing the attention layers of the transformer to identify meaningful token pairs and derive index structures for pairwise terms.

Project Supervisor: Torsten Suel (CSE); **Research Staff:** Jinrui Gou

Research Area: *Data Science/AI/Robotics*



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Improving Learned Index Structures

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Background

Traditional search engines have relied heavily on complex textual matching algorithms and frequency based ranking functions like BM25 for information retrieval. Even though they are computationally efficient, they suffer from the vocabulary mismatch problem where semantically relevant user queries do not syntactically match the keywords indexed for the documents. With the advent of transformers, search engines have started using large language models like BERT to leverage the context of the queries rather than relying solely on syntactic matching. Even though this significantly boosts the accuracy of search results, it comes with a high computational cost. One approach to balance the accuracy and efficiency at the initial stages of reranking is to use neural networks to automatically derive better inverted index structures that approximate complex transformer-based ranking.

Abstract

Our research project builds upon DeepImpact[1] that learns to score every term of a document based on its relevance. To solve vocabulary mismatch, DeepImpact utilizes an expansion model[2] trained to predict relevant queries for a passage. In addition, we use a newer approach[3] that filters out some non-relevant predicted queries as autoregressive LLMs are prone to hallucination. We also fine-tune BART and LLaMa 2 model for expansion instead of using T5. Furthermore, we explore a novel approach of analyzing the attention layers of the transformer to identify meaningful token pairs to construct index structures for pairwise terms.

Approach & Methodology

We first implemented DeepImpact by using the pre-trained BERT model and adding a fully-connected layer at the end to score every token using its hidden state. The model was trained on MS MARCO qrels dataset which consists of query, relevant document and non-relevant document triples. Given a query, the relevance score for a document was calculated as the sum of scores of intersection terms. We optimize over cross-entropy loss to maximize the score difference between relevant/non-relevant document.

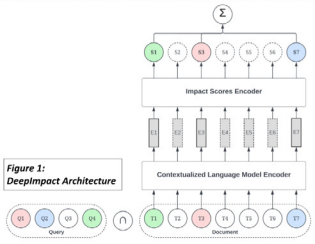


Figure 1: DeepImpact Architecture

We expand documents using docT5query as in the original paper but also use ELECTRA to filter out non-relevant queries that cannot be answered by given document. We also finetune BART & Llama 2 model using LoRA for document expansion. During the final weeks, we conceived an unexplored idea of deriving pairwise terms from attention layers—an idea we plan to implement in future.

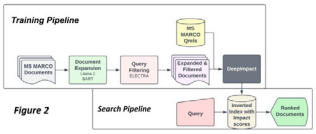


Figure 2

Evaluation & Results

We initially trained the original DeepImpact model to set the baseline. Then, we compared its performance with our method on evaluation metrics like Mean Reciprocal Ratio (MRR) and Recall. We found improvements in MRR@10 from **0.301** to **0.319**. However, Recall remained the same. This confirms that DeepImpact is still suboptimal in determining relevance scores as it requires query filter model to boost MRR. Also, using newer LLM architectures like Llama 2 exhibited better diversity in the predicted queries. However, it is still prone to hallucination.

Conclusion

Our research effectively demonstrates the potential for optimizing DeepImpact. Going forward, we plan to refine our new idea for further enhancements.

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Acknowledgement

We would like to thank NYU Tandon School of Engineering for providing us with the resources and environment to conduct this research.

DATA SCIENCE/AI/ROBOTICS

LEVERAGING LOW-POWER COMPUTER VISION FOR PEDESTRIAN COUNTING IN NEW YORK CITY

In partnership with the New York City Office of Technology & Innovation (NYC OTI), our team is developing a novel, low-power pedestrian counting solution. This solution aims to optimize city resource allocation, enhance the urban experience, and ensure privacy. Central to this prototype is an IoT board, the ESP32S3, which is equipped with a mini camera and encased in a compact camera housing. We employ a streamlined version of the YOLO v3 detection model to identify pedestrians. This is complemented by our SORT algorithm, which tracks individual pedestrians as they move across the frame. This tracking is incorporated into our line-crossing algorithm to provide accurate pedestrian counts while preserving individual privacy. No personally identifiable information is processed or stored.

For data transmission, we use low-power, long-range (LoRaWAN) frequencies that connect to The Things Network, and subsequently to AWS IoT. The aggregated data is visualized on a comprehensive dashboard, aiding NYC OTI in efficient personnel allocation, real-time decision-making, and effective long-term urban planning. To ensure our solution remains low-power, we designed a development kit that facilitates real-time power data collection. Our product has been tested and verified to operate for 86 hours on a 10,000 mAh battery at 3.7V, achieving an average accuracy of 48%. The creation of such low-power computer vision (LPCV) systems pushes the boundaries of edge-based machine learning, creating new possibilities for smart city initiatives.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Abdulaziz Alaql

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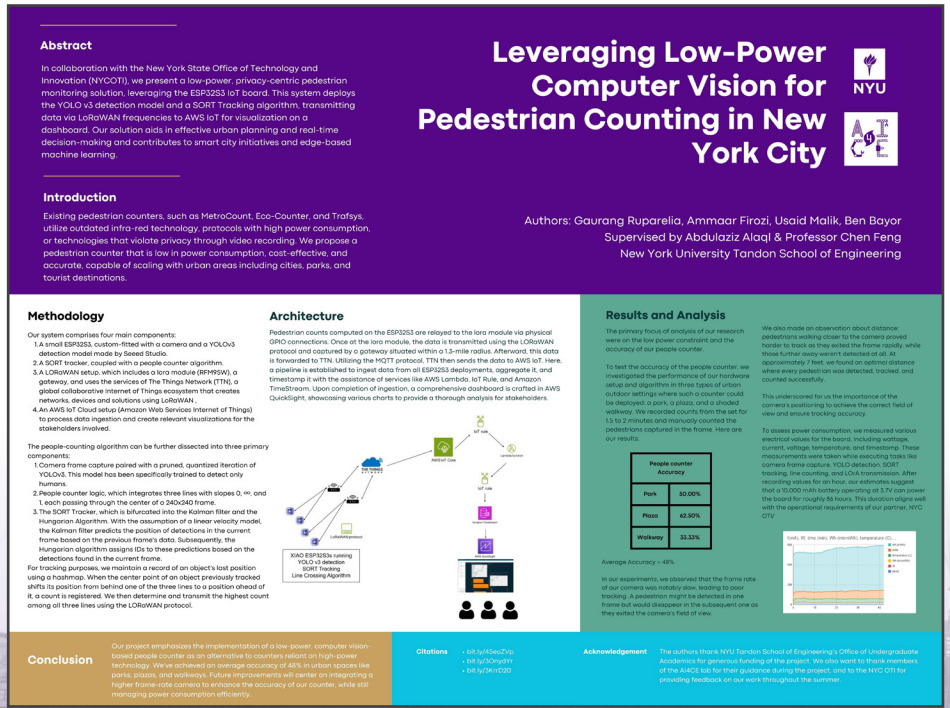
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Abstract

In collaboration with the New York State Office of Technology and Innovation (NYCOTI), we present a low-power, privacy-centric pedestrian monitoring solution, leveraging the ESP32S3 IoT board. This system deploys the YOLO v3 detection model and a SORT Tracking algorithm, transmitting data via LoRaWAN frequencies to AWS IoT for visualization on a dashboard. Our solution aids in effective urban planning and real-time decision-making and contributes to smart city initiatives and edge-based machine learning.

Introduction

Existing pedestrian counters, such as MetroCount, Eco-Counter, and Trafsys, utilize outdated infra-red technology, protocols with high power consumption, or technologies that violate privacy through video recording. We propose a pedestrian counter that is low in power consumption, cost-effective, and accurate, capable of scaling with urban areas including cities, parks, and tourist destinations.

Leveraging Low-Power Computer Vision for Pedestrian Counting in New York City

NYU

Authors: Gaurang Ruparelia, Ammaar Firozi, Usaid Malik, Ben Bayor
Supervised by Abdulaziz Alaql & Professor Chen Feng
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Methodology

Our system comprises four main components:

1. A small ESP32S3, custom-fitted with a camera and a YOLOv3 detection model made by Seeed Studio.
2. A SORT tracker, coupled with a people counter algorithm.
3. A LORaWAN setup, which includes a lora module (RPM9W), a gateway, and uses the services of The Things Network (TTN), a global collaborative internet of Things ecosystem that creates networks, devices and solutions using LoRaWAN .
4. An AWS IoT Cloud setup (Amazon Web Services Internet of Things) to process data ingestion and create relevant visualizations for the stakeholders involved.

The people-counting algorithm can be further dissected into three primary components:

1. Camera frame capture paired with a pruned, quantized iteration of YOLOv3. This model has been specifically trained to detect only humans.
2. People counter logic, which integrates three lines with slopes 0, ∞, and 1, each passing through the center of a 240x240 frame.
3. The SORT Tracker, which is bifurcated into the Kalman filter and the Hungarian Algorithm. With the assumption of a linear velocity model, the Kalman filter predicts the position of detections in the current frame based on the previous frame's data. Subsequently, the Hungarian algorithm assigns IDs to these predictions based on the detections found in the current frame.

For tracking purposes, we maintain a record of an object's last position using a hashmap. When the center point of an object previously tracked shifts its position from behind one of the three lines to a position ahead of it, a count is registered. We then determine and transmit the highest count among all three lines using the LORaWAN protocol.

Architecture

Pedestrian counts computed on the ESP32S3 are relayed to the lora module via physical GPIO connections. Once at the lora module, the data is transmitted using the LORaWAN protocol and captured by a gateway situated within a 1.3-mile radius. Afterward, this data is forwarded to TTN. Utilizing the MQTT protocol, TTN then sends the data to AWS IoT. Here, a pipeline is established to ingest data from all ESP32S3 deployments, aggregate it, and timestamp it with the assistance of services like AWS Lambda, IoT Rule, and Amazon TimeStream. Upon completion of ingestion, a comprehensive dashboard is crafted in AWS QuickSight, showcasing various charts to provide a thorough analysis for stakeholders.

Results and Analysis

The primary focus of analysis of our research were on the low power constraint and the accuracy of our people counter.

To test the accuracy of the people counter, we investigated the performance of our hardware setup and algorithm in three types of urban outdoor settings where such a counter could be deployed: a park, a plaza, and a shaded walkway. We recorded counts from the set for 1.5 to 2 minutes and manually counted the pedestrians captured in the frame. Here are our results:

People counter Accuracy	
Park	50.00%
Plaza	62.50%
Walkway	33.33%

Average Accuracy = 48%

In our experiments, we observed that the frame rate of our camera was notably slow, leading to poor tracking. A pedestrian might be detected in one frame but would disappear in the subsequent one as they exited the camera's field of view.

We also made an observation about distance: pedestrians walking closer to the camera proved harder to track as they exited the frame rapidly, while those further away weren't detected at all. At approximately 7 feet, we found an optimal distance where every pedestrian was detected, tracked, and counted successfully.

This underscored for us the importance of the camera's positioning to achieve the correct field of view and ensure tracking accuracy.

To assess power consumption, we measured various electrical values for the board, including wattage, current, voltage, temperature, and timestamp. These measurements were taken while executing tasks like camera frame capture, YOLO detection, SORT tracking, line counting, and LORA transmission. After recording values for an hour, our estimates suggest that a 10,000 mAh battery operating at 3.7V can power the board for roughly 86 hours. This duration aligns well with the operational requirements of our partner, NYC OTI.

Conclusion

Our project emphasizes the implementation of a low-power, computer vision-based people counter as an alternative to counters reliant on high-power technology. We've achieved an average accuracy of 48% in urban spaces like parks, plazas, and walkways. Future improvements will center on integrating a higher frame-rate camera to enhance the accuracy of our counter, while still managing power consumption efficiently.

Citations

- bit.ly/45eqZVp
- bit.ly/3OnydYY
- bit.ly/3KrrO2O

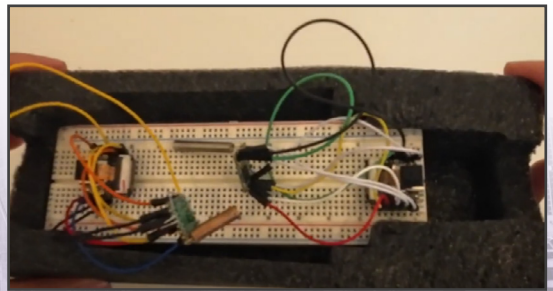
Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. We also want to thank members of the AIACE lab for their guidance during the project, and to the NYC OTI for providing feedback on our work throughout the summer.



A demonstration of the Line Crossing Algorithm using Pedestrian Tracking (featuring Gaurang Ruparelia)

LoRaWAN Protocol Hardware Setup



MECHANISM DESIGN FOR AERIAL MANIPULATION AND TRANSPORTATION

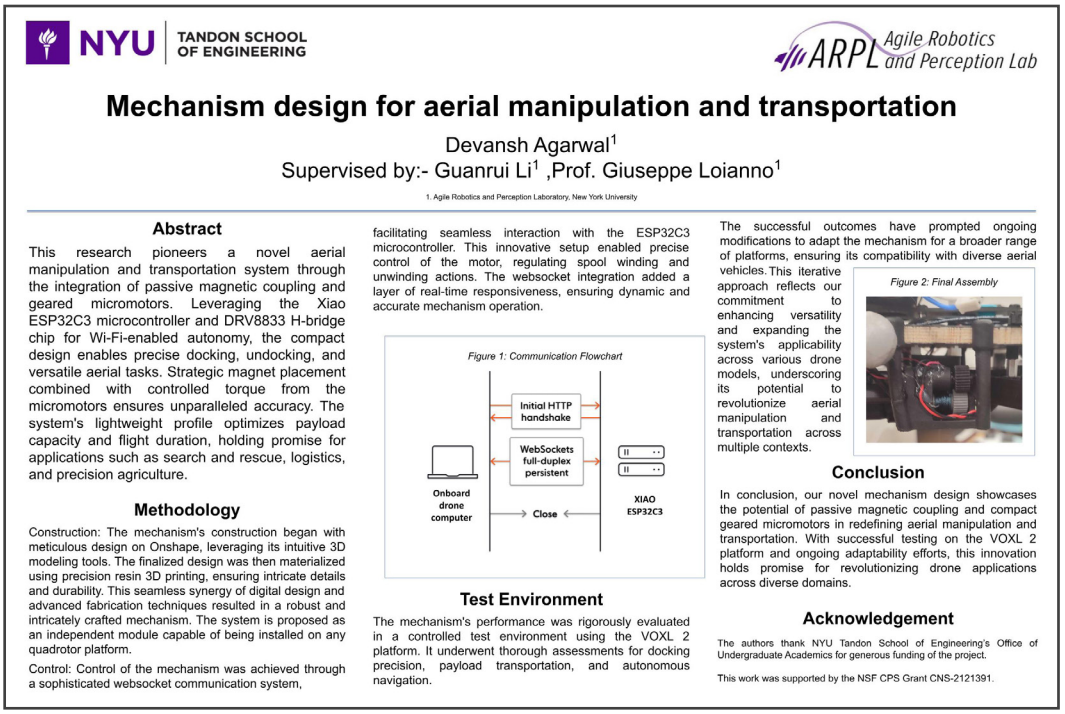
Aerial manipulation and transportation systems have garnered increasing interest due to their potential applications in diverse fields. However, traditional systems often rely on heavy actuators or bulky active components, which pose significant challenges for small drones. In this research, we propose an innovative mechanism design that leverages passive magnetic coupling and geared micromotors to address the limitations of conventional systems and enable efficient aerial manipulation and transportation. The core innovation lies in the precise placement of magnets strategically integrated into the system, along with the utilization of torque generated from two separate geared micromotors. These elements synergistically enable the drone to achieve accurate and reliable docking and undocking maneuvers. The passive coupling mechanism not only reduces weight and complexity but also ensures enhanced efficiency and robustness in real-world applications. The miniature nature of the designed system opens up new possibilities for aerial manipulation and transportation tasks in constrained environments. By employing lightweight components, the proposed design optimizes payload capacity and extends flight time, making it highly suitable for small drones with limited power resources. The system incorporates the Xiao ESP32C3 microcontroller and DRV8833 series H-bridge chip, empowering the drone with Wi-Fi capabilities for autonomous docking and undocking operations. By utilizing precise magnet placement and carefully engineered motor torque, our design enables accurate and reliable docking and undocking processes. Overall, our research contributes to the field of aerial robotics by introducing a lightweight, compact, and energy-efficient mechanism design for aerial manipulation and transportation. The use of passive magnetic coupling and geared micromotors offers a promising solution for enhancing the capabilities of small drones, opening new avenues for applications in various domains, such as search and rescue, logistics, and environmental monitoring. This work was supported by the NSF CPS Grant CNS-2121391.

Project Supervisor: Giuseppe Loianno (ECE, MAE)

Research Area: *Data Science/AI/Robotics*



Devansh Agarwal
Mechanical Engineering, B.S./M.S., 2024
NYU Tandon School of Engineering



NYU TANDON SCHOOL OF ENGINEERING

ARPL Agile Robotics and Perception Lab

Mechanism design for aerial manipulation and transportation

Devansh Agarwal[1]
Supervised by:- Guanrui Li[1] ,Prof. Giuseppe Loianno[1]

1. Agile Robotics and Perception Laboratory, New York University

Abstract

This research pioneers a novel aerial manipulation and transportation system through the integration of passive magnetic coupling and geared micromotors. Leveraging the Xiao ESP32C3 microcontroller and DRV8833 H-bridge chip for Wi-Fi-enabled autonomy, the compact design enables precise docking, undocking, and versatile aerial tasks. Strategic magnet placement combined with controlled torque from the micromotors ensures unparalleled accuracy. The system's lightweight profile optimizes payload capacity and flight duration, holding promise for applications such as search and rescue, logistics, and precision agriculture.

Methodology

Construction: The mechanism's construction began with meticulous design on Onshape, leveraging its intuitive 3D modeling tools. The finalized design was then materialized using precision resin 3D printing, ensuring intricate details and durability. This seamless synergy of digital design and advanced fabrication techniques resulted in a robust and intricately crafted mechanism. The system is proposed as an independent module capable of being installed on any quadrotor platform.

Control: Control of the mechanism was achieved through a sophisticated websocket communication system, facilitating seamless interaction with the ESP32C3 microcontroller. This innovative setup enabled precise control of the motor, regulating spool winding and unwinding actions. The websocket integration added a layer of real-time responsiveness, ensuring dynamic and accurate mechanism operation.

Figure 1: Communication Flowchart

Test Environment

The mechanism's performance was rigorously evaluated in a controlled test environment using the VOXL 2 platform. It underwent thorough assessments for docking precision, payload transportation, and autonomous navigation.

The successful outcomes have prompted ongoing modifications to adapt the mechanism for a broader range of platforms, ensuring its compatibility with diverse aerial vehicles. This iterative approach reflects our commitment to enhancing versatility and expanding the system's applicability across various drone models, underscoring its potential to revolutionize aerial manipulation and transportation across multiple contexts.

Figure 2: Final Assembly

Conclusion

In conclusion, our novel mechanism design showcases the potential of passive magnetic coupling and compact geared micromotors in redefining aerial manipulation and transportation. With successful testing on the VOXL 2 platform and ongoing adaptability efforts, this innovation holds promise for revolutionizing drone applications across diverse domains.

Acknowledgement

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

This work was supported by the NSF CPS Grant CNS-2121391.

MOBILE 3D CLAY PRINTING

The scale of traditional additive manufacturing, constrained by the dimensions of box-like 3D printing machinery, limits its application in industrial settings. To overcome this limitation, our project introduces an innovative approach, leveraging a 6 DoF (Degree of Freedom) Universal Robot arm equipped with a clay printing head, setting a new precedent for 3D printing with fluid-like materials and a ROS (Robot Operating System)-based communication workflow. By harnessing the capabilities of Moveit!, a sophisticated motion planning framework, the collaborative UR10e robot arm achieves millimeter-level precision in end-effector translation and rotation. Despite this advancement, we must address the inherent unpredictability of fluid-like materials, whose flow rates vary continuously rather than being binary. This issue highlights the age-old problem of defect detection in additive manufacturing. Our solution employs an Intel RealSense Stereo Depth camera to capture depth point clouds during the printing process. After transforming these point clouds into the world frame and denoising them, we can reconstruct the printed object and conduct real-time comparisons with a ground truth model, effectively identifying any defects. The overarching goal of this project is to supplement human labor with autonomous robots, liberating workers from hazardous environments and hastening civil engineering construction processes. This venture not only propels additive manufacturing to new frontiers but also contributes to creating safer, more efficient workplaces.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Xuchu Xu

Research Area: *Data Science/AI/Robotics*



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Computer Science, B.S., 2024
NYU Shanghai

NYU TANDON SCHOOL OF ENGINEERING

3D Clay Printing with Real-time Defect Detection

Yongyu Liu,[1] Xuchu Xu,[2] Junyang Tang,[3] Chen Feng[4]

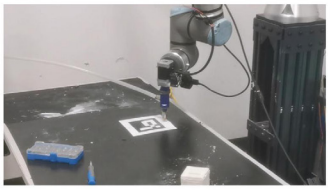
1. Student Researcher, NYUSH 2. Mentor, NYU 3. Student Researcher, NYU 4.Supervisor, NYU

Abstract

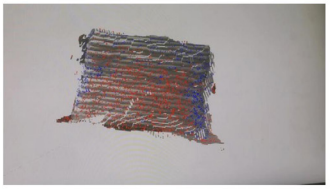
The scale of traditional additive manufacturing, constrained by the dimensions of box-like 3D printing machinery, limits its application in industrial settings. To overcome this limitation, our project introduces an innovative approach, leveraging a 6 DoF (Degree of Freedom) Universal Robot arm equipped with a clay printing head, setting a new precedent for 3D printing with fluid-like materials and a ROS -based communication workflow. By harnessing the capabilities of Moveit!, a sophisticated motion planning framework, the collaborative UR10e robot arm achieves millimeter-level precision in end-effector translation and rotation. Despite this advancement, we must address the inherent unpredictability of fluid-like materials, whose flow rates vary continuously rather than being binary. This issue highlights the age-old problem of defect detection in additive manufacturing. Our solution employs a depth camera to capture depth point clouds during the printing process. After transforming these point clouds into the world frame and denoising them, we can reconstruct the printed object and conduct real-time comparisons with a ground truth model, effectively identifying any defects.

Methodology

Hardware: Air pump, clay tank, transportation pipe, stepper motor, printhead are connected in sequence to give out clay. The printhead is mounted on the robot arm and serves as the end effector.



Software: For 3D reconstruction, we transform point clouds captured by the depth camera into world frame by hand-eye calibration, and merge them into the world frame. We denoise the point cloud by cropping out the field of interest and removing radius and statistical outliers. We compare the reconstructed object and the model point cloud using Chamfer distance, then filter out points with distance beyond threshold.

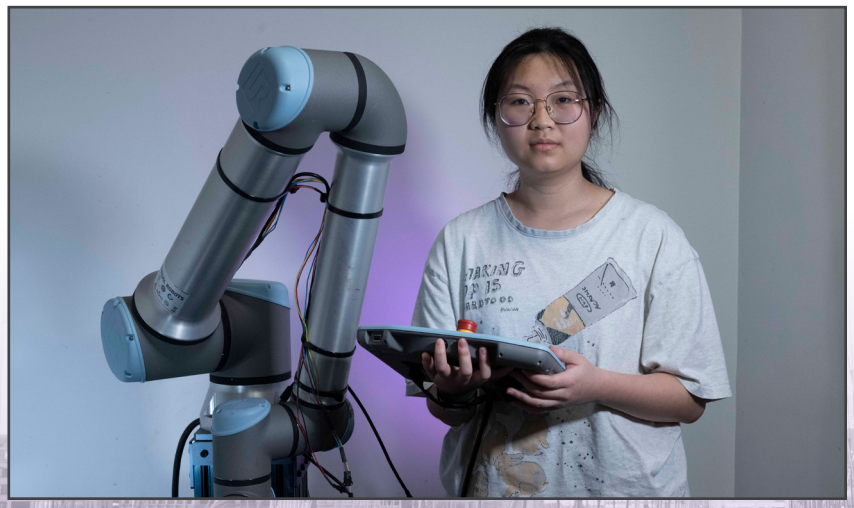


Conclusion

The overarching goal of this project is to supplement human labor with autonomous robots, liberating workers from hazardous environments and hastening civil engineering construction processes. This venture not only propels additive manufacturing to new frontiers but also contributes to creating safer, more efficient workplaces.

Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks to the support of AI4CE lab.



MUJOCO MODELING AND SIMULATION

Motors are quintessential to many engineering projects as their job is to convert electrical energy to mechanical, and they are best understood by testing them. Motor testing is carried out to identify the parameters of a motor and predict certain behaviors. This work is focused on running and validating an existing motor testing setup in Webots simulation by comparing experimentally-obtained and predefined parameters. Data is taken from running the simulation with different desired torque values. The following significant relationships are found using the measured data: the negative desired and measured torque values show an identical relationship, and the angular velocity of the motor has a linear relationship with negative desired torque. Positive desired torque values present a problem when trying to run the simulation as they cause the lever arm to flip up and away from the load cell. The simulation could be improved to allow positive desired torque values by increasing the weight of the lever arm or adding a block to keep the lever arm in place. A further step in future work could be working with the actual motor testing setup outside the simulation and finding other parameters such as positive external torque and non-steady state.

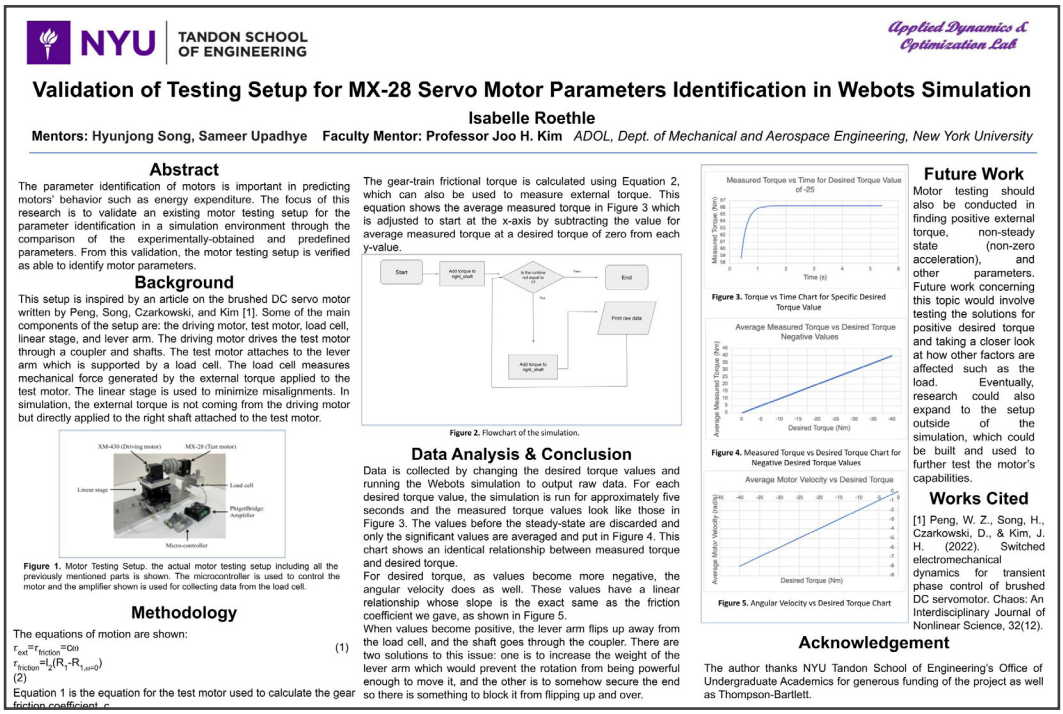
Project Supervisor: Joo H. Kim (MAE); **Research Staff:** William Z. Peng, Hyunjong Song, Sameer Upadhye, Stacy Ashlyn

Research Areas: *Data Science/AI/Robotics, Sustainability*



Isabelle Roethle
Mechanical Engineering, B.S., 2025
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Thompson-Bartlett Fellow



NYU TANDON SCHOOL OF ENGINEERING

Applied Dynamics & Optimization Lab

Validation of Testing Setup for MX-28 Servo Motor Parameters Identification in Webots Simulation

Isabelle Roethle

Mentors: Hyunjong Song, Sameer Upadhye **Faculty Mentor: Professor Joo H. Kim** *ADOL, Dept. of Mechanical and Aerospace Engineering, New York University*

Abstract

The parameter identification of motors is important in predicting motors' behavior such as energy expenditure. The focus of this research is to validate an existing motor testing setup for the parameter identification in a simulation environment through the comparison of the experimentally-obtained and predefined parameters. From this validation, the motor testing setup is verified as able to identify motor parameters.

Background

This setup is inspired by an article on the brushed DC servo motor written by Peng, Song, Czarkowski, and Kim [1]. Some of the main components of the setup are: the driving motor, test motor, load cell, linear stage, and lever arm. The driving motor drives the test motor through a coupler and shafts. The test motor attaches to the lever arm which is supported by a load cell. The load cell measures mechanical force generated by the external torque applied to the test motor. The linear stage is used to minimize misalignments. In simulation, the external torque is not coming from the driving motor but directly applied to the right shaft attached to the test motor.

Figure 1. Motor Testing Setup. the actual motor testing setup including all the previously mentioned parts is shown. The microcontroller is used to control the motor and the amplifier shown is used for collecting data from the load cell.

Methodology

The equations of motion are shown:

$$\tau_{ext} = \tau_{friction} = c\omega \quad (1)$$

$$\tau_{friction} = I_2(R_1 - R_{1,\omega=0}) \quad (2)$$

Equation 1 is the equation for the test motor used to calculate the gear friction coefficient, c.

The gear-train frictional torque is calculated using Equation 2, which can also be used to measure external torque. This equation shows the average measured torque in Figure 3 which is adjusted to start at the x-axis by subtracting the value for average measured torque at a desired torque of zero from each y-value.

Figure 2. Flowchart of the simulation.

Data Analysis & Conclusion

Data is collected by changing the desired torque values and running the Webots simulation to output raw data. For each desired torque value, the simulation is run for approximately five seconds and the measured torque values look like those in Figure 3. The values before the steady-state are discarded and only the significant values are averaged and put in Figure 4. This chart shows an identical relationship between measured torque and desired torque.

For desired torque, as values become more negative, the angular velocity does as well. These values have a linear relationship whose slope is the exact same as the friction coefficient we gave, as shown in Figure 5.

When values become positive, the lever arm flips up away from the load cell, and the shaft goes through the coupler. There are two solutions to this issue: one is to increase the weight of the lever arm which would prevent the rotation from being powerful enough to move it, and the other is to somehow secure the end so there is something to block it from flipping up and over.

Figure 3. Torque vs Time Chart for Specific Desired Torque Value

Figure 4. Measured Torque vs Desired Torque Chart for Negative Desired Torque Values

Figure 5. Angular Velocity vs Desired Torque Chart

Future Work

Motor testing should also be conducted in finding positive external torque, non-steady state (non-zero acceleration), and other parameters. Future work concerning this topic would involve testing the solutions for positive desired torque and taking a closer look at how other factors are affected such as the load. Eventually, research could also expand to the setup outside of the simulation, which could be built and used to further test the motor's capabilities.

Works Cited

[1] Peng, W. Z., Song, H., Czarkowski, D., & Kim, J. H. (2022). Switched electromechanical dynamics for transient phase control of brushed DC servomotor. Chaos: An Interdisciplinary Journal of Nonlinear Science, 32(12).

Acknowledgement

The author thanks NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project as well as Thompson-Bartlett.

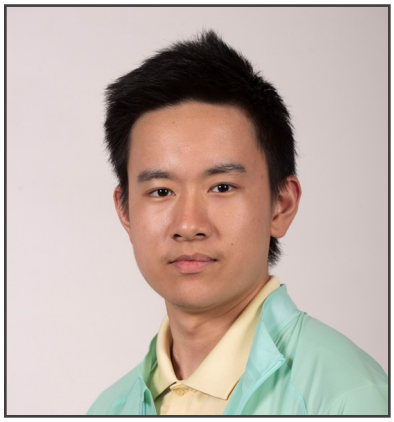
RECURRENT NEURAL NETWORK BASED INERTIAL ODOMETRY WITHIN SIX DEGREES OF FREEDOM

The proliferation and technological maturity of inertial measurement units (IMU) facilitate their use as low-cost position tracking tools. The IMU typically consists of the accelerometer and gyroscope, which measures linear and angular accelerations along each axis of three dimensional space. Thus, the IMU's data stream across such six degrees of freedom can provide sophisticated information about the IMU's motion, but this insight is usually greatly hampered by measurement noise and bias. Without processing and filtering IMU data, such inaccuracies diminish the IMU's utility as an easily deployable and widely available odometry tool.

Addressing these issues, various learning-based approaches involving recurrent neural networks (RNN) and other deep neural networks have emerged from the advancements in machine learning. Learning-based strategies often surpass traditional modeling techniques by being data-driven and possessing a lower deployment overhead due to tuning and calibration. In this work, the performance gains from deploying the Long Short-Term Memory (LSTM) RNN is investigated on the positional estimations made by an Android device's IMU. Comparative experiments are conducted to evaluate the efficacy differences between traditional filtering techniques and LSTM approaches. An original data collection and processing pipeline merges IMU data for network training purposes and ground-truth information, the latter of which is derived from the existing visual localization framework in the UNav infrastructure. The developed RNN algorithm is evaluated on the UNav infrastructure's user-oriented navigation application.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Anbang Yang

Research Area: *Data Science/AI/Robotics*



Ge (James) Jin
Computer Science, B.S., 2026
NYU Tandon School of Engineering

RESPONSE OF AIR-BACKED COMPOSITE PANELS TO HYDRODYNAMIC LOADING

Understanding the dynamic response of composites structures at freezing temperature is essential to the design of marine vessels operating in extreme environmental conditions. While previous studies focused on the structural deformation due to impact and pointwise measurements of the fluid's pressure, the influence of cold temperatures on the vibrational response under hydrodynamic loading remained untapped. From the technical literature it is known that the herein investigated composite plates show a drastic reduction of their compression modulus at cold temperatures. In this study, a series of experiments is conducted to study the vibration of composite structures, in both cold and room temperature. A circular composite panel is placed in contact with water on one side inside of a tank. A hydraulic actuator is utilized to induce pressure loading, and two high speed cameras are used to record the dynamic response.In particular, we utilize digital image correlation (DIC) and particle image velocimetry (PIV) to quantify the plate vibration and fluid flow. Specifically, we investigate the center-point deflection, vibration modes, and pressure loading. In addition, an image segmentation model is built upon and employed to aid in automating the PIV analysis process. Our results show no statistically significant difference in the structural response of the fiberglass-reinforced epoxy plates in cold and room temperature environments. This seemingly disappointing result unraveled the importance of the previously neglected prestress due to the hydrostatic pressure and is opening up new research questions regarding the role of the bimodular material behavior of composite plates in cold temperatures.

Project Supervisor: Maurizio Porfiri (CUSP, MAE, BME); **Research Staff:** Nicco Ulbricht

Research Area: *Data Science/AI/Robotics*



Evan Laljit
Physics B.S./Mechanical Engineering B.S., 2025
NYU College of Arts & Science/
Tandon School of Engineering

Combined Effect of Fluid-Structure Interactions and Extreme Low Temperatures on the Dynamic Response of Marine Composites

Evan Laljit
Mentors: Nicco Ulbricht
PI: Maurizio Porfiri
Department of Mechanical and Aerospace Engineering

NYU TANDON SCHOOL OF ENGINEERING

Dynamical systems laboratory

NSF

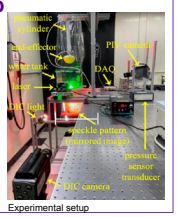
Summer 2023

Background

Understanding the dynamic response of composite structures is essential to the design of marine vessels operating in extreme temperature conditions. Previous studies have focused on the structural and fluid response in room temperature, leading the analysis of fluid-structure interactions for cold temperatures largely unexplored. We seek to fill in this gap by studying the vibrational behavior of composite plates in both cold temperature (5 C) and room temperature (20 C).

Experimental Setup

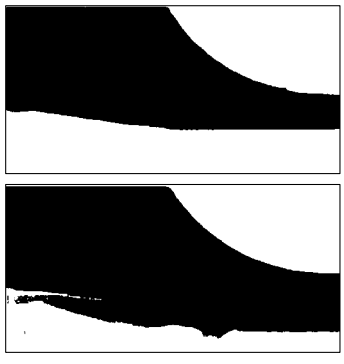
- Digital image correlation (DIC) is used to reconstruct the plate deformation during vibrations
- Particle image velocimetry (PIV) used to reconstruct fluid velocity using displacement of particles placed in fluid



Experimental setup

Image Segmentation Model

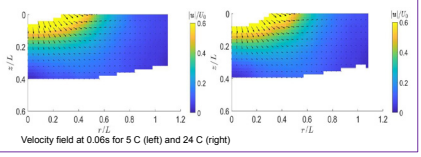
- Based on an open-source image segmentation model, an image process toolbox was built to edit, crop and mask the PIV images
- It was found that masking quality heavily relies on the quality of the image, to properly identify each object and its boundaries



High-quality mask (top) and poor-quality mask (bottom)

Fluid Flow

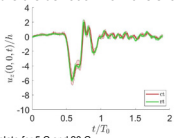
- Velocity field obtained using PIVLAB in MATLAB and MATLAB code
- Results show that the fluid flow is coupled to the plate vibrations



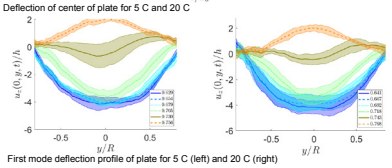
Velocity field at 0.06s for 5 C (left) and 24 C (right)

Structural Dynamics

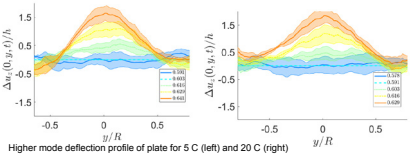
- DIC measures plate deflection via images taken by high speed camera
- Plate vibration shapes show no significant statistical difference for cold and room temperature
- 1st mode vibrations resemble shape in a vacuum and higher order vibrations measure the deviation from this shape



Deflection of center of plate for 5 C and 20 C



First mode deflection profile of plate for 5 C (left) and 20 C (right)



Higher mode deflection profile of plate for 5 C (left) and 20 C (right)

Future Work

- Work on image segmentation model
- Improve experiments

This study will contribute to understanding the structural and fluid dynamics of composite plates under dynamic loading in cold temperatures.

References

[1] Zhang P, Guo Y, Porfiri M. (2023) An experimental methodology to study impulsive hydrodynamic loading of air-backed composite plates. *Journal of Sandwich Structures & Materials*, 0(0), 10.1177/1099636223/1151457

Contact

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THE ROBOTICIZATION OF THE WADDLE: ANALYZING DIFFERENCES BETWEEN KING AND GENTOO PENGUIN BIOMECHANICAL MODELS FOR IMPROVED BIPEDAL ROBOT HARDWARE DESIGN

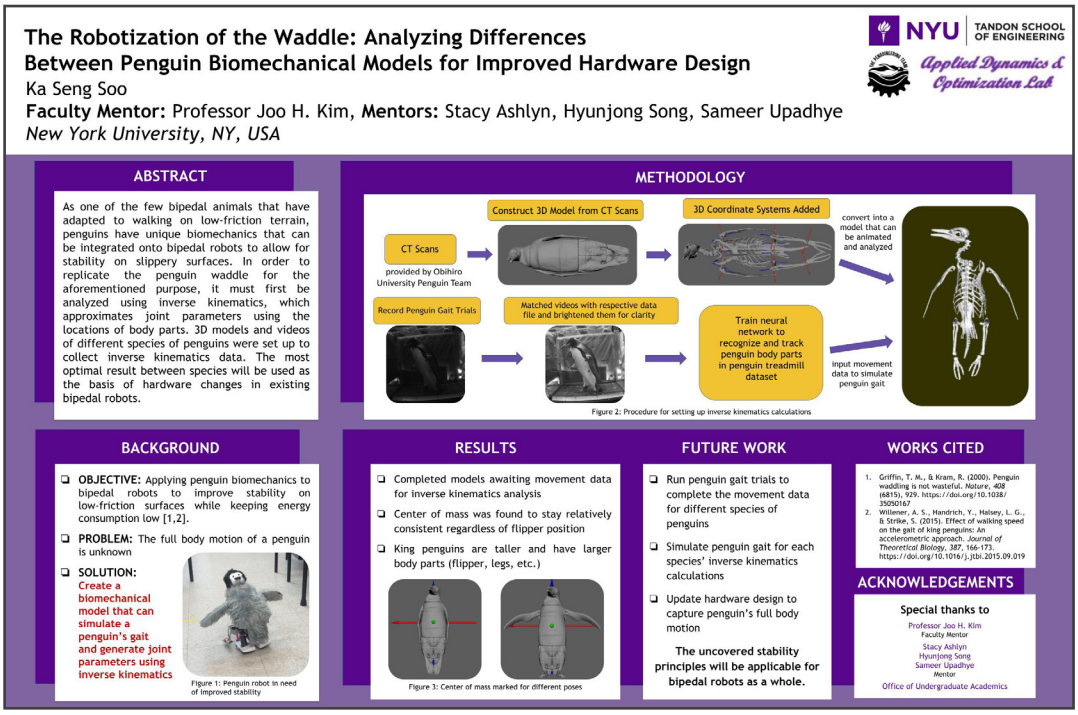
Bipedal robots have been a topic of interest for many years due to their wide range of applications, such as aiding in rehabilitation or carrying out tasks in dangerous environments. However, a core problem plaguing bipedal robots is maintaining stability, especially when walking over low-friction surfaces. A possible solution can be found in nature by observing a bipedal animal that has adopted a unique gait to traverse slippery terrain: the penguin. This research focuses on the mechanics behind the penguin waddle and how it enables low-friction locomotion. Using CT scans of various penguins, 3D models of a king penguin and a gentoo penguin were constructed. Then, to allow for movement and animation, three-dimensional coordinate systems were added to the joints of the penguin models and uploaded onto OpenSim, a biomechanical simulation software. Through OpenSim, the 3D models are able to run simulations of each type of penguin's gait and perform analysis, given enough experimental data of actual penguin movements. In addition, the center of mass of each penguin was calculated, which supplements the anatomical difference data obtained from the gait simulations. These tools allow for the study of how differences in anatomy affect a penguin's gait, which will be useful in understanding how changes in hardware would affect bipedal robot walking.

Project Supervisor: Joo H. Kim (MAE); **Research Staff:** Stacy Ashlyn, Hyunjong Song, Sameer Upadhye

Research Areas: *Data Science/AI/Robotics, Urban*



Ka Seng Soo
Mechanical Engineering, B.S., 2025
NYU Tandon School of Engineering



SENSOR SUITE DESIGN FOR AUTONOMOUS DRONE RACING

The advancement of autonomous robot racings has indicated the need for precise and efficient sensor systems to enhance navigation of racing robots. This portfolio presents a study on the design and integration of a sensor suit for autonomous racing robots, utilizing the LADAR. The purpose of this research is to develop a comprehensive sensor suite that enables accurate localization, with addressing the mechanical and electrical challenges associated with mounting and wiring. This research involved careful approach to utilize LADAR in full efficiency. To achieve this, multiple CAD models and testings were made, to reduce the weights of the CAD parts and to have clean wirings, to not inhibit the robot's performance. In order to create most efficient sensor suite for this project, CAD designs and schematics designs tools, such as fusion360 and altium were used. The robot successfully navigated and located with the installed LADAR.

Project Supervisor: Giuseppe Loianno (ECE, MAE)

Research Area: *Data Science/AI/Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Sensor Suit Design for Autonomous Racing

Elodie Choi

Abstract

The advancement of autonomous robot racings has indicated the need for precise and efficient sensor systems to enhance navigation of racing robots. This portfolio presents a study on the design and integration of a sensor suit for autonomous racing robots, utilizing the LADAR. The purpose of this research is to develop a comprehensive sensor suite that enables accurate localization, with addressing the mechanical and electrical challenges associated with mounting and wiring. This research involved careful approach to utilize LADAR in full efficiency. To achieve this, multiple CAD models and testings were made, to reduce the weights of the CAD parts and to have clean wirings, to not inhibit the robot's performance. In order to create most efficient sensor suite for this project, CAD designs and schematics designs tools, such as Fusion360 and altium were used. The robot successfully navigated and located with the installed LADAR.

Background on the Project

LADAR (Laser Detection and Ranging) is a sensor that functions by using light to determine the distance to an object and create detailed 3D representations of environments. In detail, LADAR let out pulses of light and measure the time it takes for light to reflect back to the sensor. [1]By analyzing, distance could be calculated quickly.

Utilizing LADAR was important because such system gave significant benefits on autonomous driving of the robot. With such quick distance determiner, LADAR was useful for the robot to not crash. Our team wanted to use LADAR in the ground, to calculate the distance from the robot and to the nearest ground. In order to achieve this, mounts were necessary.

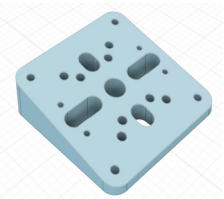


Figure 1: LADAR Mount

Because the angle of LADAR sensing needed to be perpendicular while the robot was flying in angled direction, it was necessary to create the mount slightly angled to counteract the angled flying tendency of the robot. With multiple trial and error, the mount could be created. These angles were then implemented by creating CAD models of specialized mounts that allowed for flexible adjustments.

Test Environment

The testing was successfully completed, as the distance was successfully calculated.

Eventually, multiple testings were conducted for trial and errors.



Figure 2: Robot Flying off



Figure 3: Robot Flying in air

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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 can go to others (Thompson-Bartlett, for instance).

DATA SCIENCE/AI/ROBOTICS

SMART WEARABLE SENSING AND SOFT ROBOTICS

The field of robotics has proven to be revolutionary and immensely versatile, with modern life as we know it unable to exist without its innovations and few aspects of our lives able to remain wholly untouched by its reach. With applications ranging from automation in manufacturing and agriculture to marine and space exploration, another rapidly developing and expanding area with more direct contact in our lives is medicine and healthcare, with currently existing robots that are able to assist with surgery, robots that can help with rehabilitation, patient prosthetics, and much more. This research project focuses specifically on potential applications such as medical monitoring and rehabilitation, with this project aiming to decode muscle functionality with a wearable solution in an innovative approach in soft robotics. We worked to design, create, and develop a frame/mount to collect and interpret hand-tracking data from a camera source, a system to render 3D hand models in real-time based on this collected data as well as data from other external sources such as sensors, and a smart wearable wristband equipped with accelerometers to detect hand movements. With our collected data, our methodology involves training a machine learning model to predict hand gestures in real-time, focusing particularly on data collected from the carpus region. We postulate that with a fully trained model, we will be able to predict hand gestures solely using accelerometer data from the smart wristband, demonstrating the possibility of decoding muscle functionality without relying on additional external sensors or cameras.

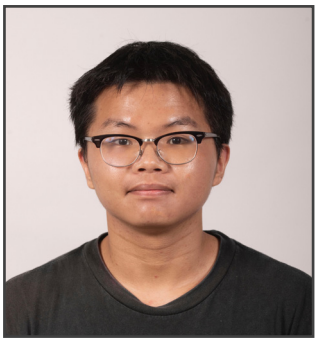
Project Supervisor: S. Farokh Atashzar (ECE, MAE, BME, CSE)

Research Areas: *Data Science/AI/Robotics, Health*



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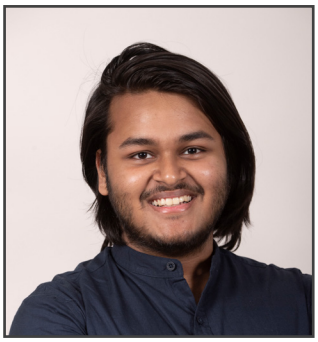
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NYU TANDON SCHOOL OF ENGINEERING

MERIIT Medical Robotics and Interactive Intelligent Technologies Laboratory NYU

Smart Wearable Sensing & Soft Robotics

Wentao Chen, Yun Hao Dong, Salman Elgamal, Yaghyesh Ghimire, Swostik Pati

MERIIT Lab, NYU Tandon Undergraduate Summer Research Program

Abstract

This research project focuses on specific applications of the field of robotics in areas such as medical monitoring and rehabilitation, particularly aiming to decode muscle functionality with a wearable solution in an innovative approach in soft robotics. We worked to design, create, and develop a frame/mount to collect and interpret hand-tracking data from a camera source, a system to render 3D hand models in real-time based on this collected data, and a smart wearable wristband equipped with accelerometers to detect hand movements.

Background

The field of robotics has proven to be incredibly revolutionary and immensely versatile, with modern life as we know it unable to exist without its innovations and few aspects of our lives able to remain wholly untouched by its reach. With applications ranging from automation in manufacturing and agriculture to marine and space exploration, another rapidly developing and expanding area with more direct contact in our lives is medicine and healthcare, with currently existing and additional potential future robots that are able to assist with surgery, rehabilitation, patient prosthetics, and much more, which is the focus of this project.

Process

Understanding and extracting the data from the Ultraleap served as a key starting point of our investigation. To establish an optimal data collection setting, we needed to create a stable platform for arms to rest at a position relative to the Ultraleap device. We fabricated multiple prototypes using cardboard. Based on our preliminary findings, we then advanced to a more robust design, employing wood for the primary structure, 3D printed arm rests, and a mount to securely the Ultraleap device.

Our next objective was to render a 3D model of our hand in the Unity environment, making use of the data collected from external sensors. We achieved this by creating and executing two parallel scripts: A Python script processed the data received from the webcam via the CVZone hand tracking library, and this processed data was subsequently relayed to Unity using a UDP data socket network. Within Unity, we leveraged two C# scripts to render a real-time, 3D skeleton model of our hand gestures.



Figures 1, 2. Ultraleap's hand tracking capabilities

Results

This research project successfully developed a hand tracking system and a design for a tendon movement data collection system, integrating the Ultraleap device, Unity, and OpenCV python library. The system provided accurate hand tracking by rendering the tracked hands within the Unity environment and also in OpenCV-based camera. A custom frame, composed of 3D printed components and wood, ensured uniform data collection with minimal interference during hand movements. We also developed a blueprint of a smart wristband equipped with an Arduino Nano Microcontroller and three accelerometers in the carpus area mounted over a PCB to capture precise tendon movement while various hand gestures are being made.



Figure 3. Rendering our hands in Unity



Figure 4. Hand tracking frame

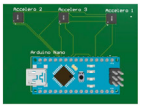


Figure 5. PCB Design Prototype

Future Work

Our next step is to have the wristband with functional wiring schematic and PCB design manufactured. It will be synced with our frame and hand rendering tools for data collection, and then ultimately pair with a machine learning model to predict hand gestures in real-time, focusing particularly on data collected from the carpus region. We postulate that with a fully trained model, we will be able to predict hand gestures solely using accelerometer data from the smart wristband, demonstrating an ability to decode muscle functionality without relying on additional external sensors or cameras.

Acknowledgements

We extend our deepest gratitude to our project advisor, Professor S. Farokh Atashzar, whose supervision and mentorship have been invaluable throughout the entirety of this project. We would also like to acknowledge the dedicated support and guidance from the research mentors - Sarmad Mehrdad, Erin Hu, Mohammedali Roowala, and Joycephine Li.

SPARSE OPTIMIZATION IN MATRIX RECOVERY USING DUAL REPRESENTATION AND PROXIMAL METHODS

Abstract: Sparse optimization has emerged as a powerful tool in solving various matrix recovery problems, such as image restoration, signal denoising, and compressed sensing. This work addresses the problem of minimizing an objective function that combines a quadratic data fidelity term with a non-smooth ℓ_1-norm regularization term. Specifically, we aim to find the optimal solution for the objective function $1/2||Ax-b||_2^2 + \lambda||Bx||_1$, where A is the measurement matrix, b is the observed data, B is an arbitrary matrix, and x is the vector to be recovered. To tackle this optimization problem, we employ the dual representation of the ℓ_1-norm and leverage Sion's minimax theorem. This approach enables us to rewrite the ℓ_1-norm term as a supremum over a vector z, which satisfies a constraint involving the $\ell\infty$-norm of z. Subsequently, we transform the original objective function into an equivalent form involving the supremum and an infimum over a quadratic function of x and z.

To solve the optimization problem effectively, we propose employing a projected gradient algorithm. The gradient of the objective function with respect to z is derived as $a + \lambda Sz$, where a is a vector related to the data and Sz belongs to the null space of BB^T. The projection step can be performed efficiently, allowing us to find the sparse and accurate solution for x. In summary, our approach leverages the dual representation and proximal methods to efficiently solve the sparse optimization problem in matrix recovery, offering a powerful tool for various applications in signal and image processing.

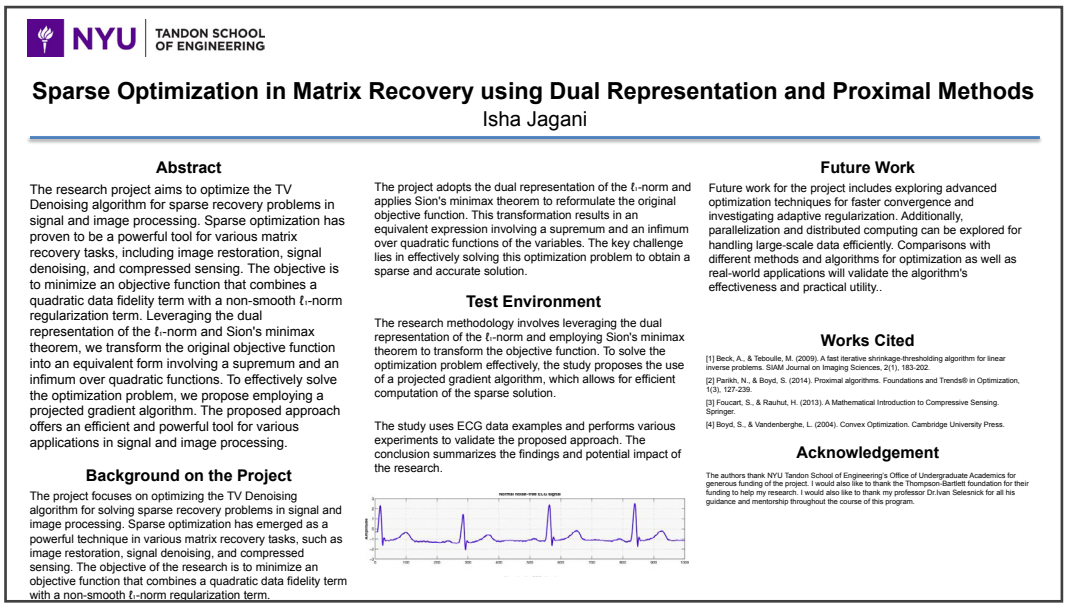
Project Supervisor: Ivan Selesnick (ECE)

Research Area: *Data Science/AI/Robotics*



Isha Jagani
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NYU TANDON SCHOOL OF ENGINEERING

Sparse Optimization in Matrix Recovery using Dual Representation and Proximal Methods

Isha Jagani

Abstract

The research project aims to optimize the TV Denoising algorithm for sparse recovery problems in signal and image processing. Sparse optimization has proven to be a powerful tool for various matrix recovery tasks, including image restoration, signal denoising, and compressed sensing. The objective is to minimize an objective function that combines a quadratic data fidelity term with a non-smooth ℓ_1-norm regularization term. Leveraging the dual representation of the ℓ_1-norm and Sion's minimax theorem, we transform the original objective function into an equivalent form involving a supremum and an infimum over quadratic functions. To effectively solve the optimization problem, we propose employing a projected gradient algorithm. The proposed approach offers an efficient and powerful tool for various applications in signal and image processing.

Background on the Project

The project focuses on optimizing the TV Denoising algorithm for solving sparse recovery problems in signal and image processing. Sparse optimization has emerged as a powerful technique in various matrix recovery tasks, such as image restoration, signal denoising, and compressed sensing. The objective of the research is to minimize an objective function that combines a quadratic data fidelity term with a non-smooth ℓ_1-norm regularization term.

The project adopts the dual representation of the ℓ_1-norm and applies Sion's minimax theorem to reformulate the original objective function. This transformation results in an equivalent expression involving a supremum and an infimum over quadratic functions of the variables. The key challenge lies in effectively solving this optimization problem to obtain a sparse and accurate solution.

Test Environment

The research methodology involves leveraging the dual representation of the ℓ_1-norm and employing Sion's minimax theorem to transform the objective function. To solve the optimization problem effectively, the study proposes the use of a projected gradient algorithm, which allows for efficient computation of the sparse solution.

The study uses ECG data examples and performs various experiments to validate the proposed approach. The conclusion summarizes the findings and potential impact of the research.

Future Work

Future work for the project includes exploring advanced optimization techniques for faster convergence and investigating adaptive regularization. Additionally, parallelization and distributed computing can be explored for handling large-scale data efficiently. Comparisons with different methods and algorithms for optimization as well as real-world applications will validate the algorithm's effectiveness and practical utility..

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. I would also like to thank the Thompson-Bartlett foundation for their funding to help my research. I would also like to thank my professor Dr.Ivan Selesnick for all his guidance and mentorship throughout the course of this program.

SPATIAL REASONING

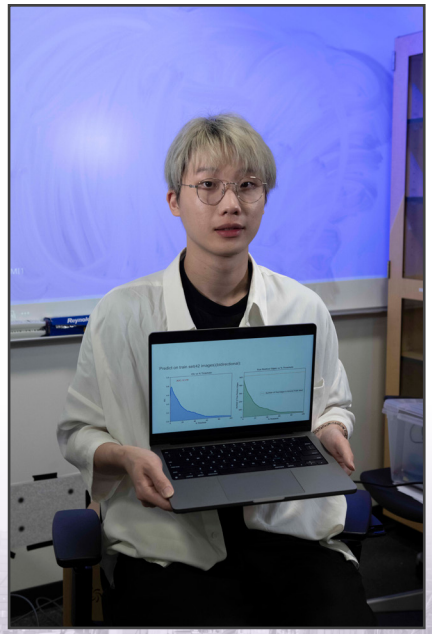
Spatial reasoning has long been a fundamental challenge in computer vision. In this project, our primary objective is to tackle a critical issue within the spatial reasoning domain: the long baseline matching of perspective RGB images with minimal overlap. Specifically, we aim to determine whether two images are spatially accessible to each other, effectively transforming the problem into a binary classification task. To address this challenge, our work focuses on generating a simulated dataset using the habitatsim environment. By creating this dataset, we aim to provide a broader array of examples that better understand the long baseline matching problem. Also, we conduct comprehensive ablation studies using various baselines, feature-matching techniques such as superglue and supervised learning methods like VGG16 and ViT_B16_224. Additionally, we explore unsupervised approaches, RANSAC/SIFT and NetVlad, along with object-matching algorithms like CSR (Continuous Scene Representation) for benchmarking purposes. The outcome of this research is expected to draw more attention to the challenges and potential solutions in long baseline matching of perspective RGB images. By shedding light on this critical issue, we aim to stimulate further research and innovations for others to explore this problem.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Wenyu Han

Research Area: *Data Science/AI/Robotics*



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Spatial reasoning

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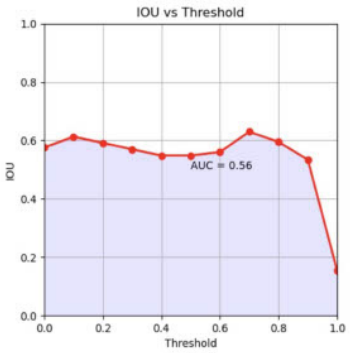
Abstract

Specifically, we aim to determine whether two images are spatially accessible to each other, effectively transforming the problem into a binary classification task. To address this challenge, our work focuses on generating a simulated dataset using the habitatsim environment. The outcome of this research is expected to draw more attention to the challenges and potential solutions in long baseline matching of perspective RGB images. By shedding light on this critical issue, we aim to stimulate further research and innovations for others to explore this problem.

Background on the Project

Spatial reasoning has long been a fundamental challenge in computer vision. In this project, our primary objective is to tackle a critical issue within the spatial reasoning domain: the long baseline matching of perspective RGB images with minimal overlap.

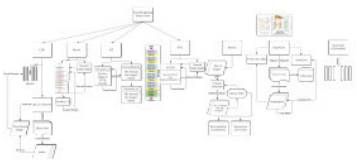
Figure 1: IOU example



Methodology

By creating the habitats dataset, we aim to provide a broader array of examples that better understand the long baseline matching problem. Also, we conduct comprehensive ablation studies using various baselines, feature-matching techniques such as superglue and supervised learning methods like VGG16 and ViT_B16_224. Additionally, we explore unsupervised approaches, RANSAC/SIFT and NetVlad, along with object-matching algorithms like CSR (Continuous Scene Representation) for benchmarking purposes. Also, we would like to use contrastive learning in a novel approach to enhance our performance.

Figure 2: Overview of our baselines



Observation/conclusion

Regarding the generation of our dataset, we are currently encountering minor challenges in the creation of ground truth labels. These issues are being addressed with the utmost priority to ensure the integrity of our data. In terms of our baseline study, the Vision Transformer (ViT) appears to be the most suitable model for our task at the present moment. Furthermore, we are in the process of implementing innovative methodologies that we anticipate will enhance our performance.

Acknowledgement

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

SURE BASED APPROACH TO SETTING REGULARIZATION PARAMETERS FOR SIGNAL DENOISING WITH COMPOUND REGULARIZATION

Noise is a common occurrence when measuring data in various areas of science. Thus signal denoising, the process of removing noise to obtain the desired unknown signal, has many applications. In 2021, Dai et al. proposed a method of signal denoising for eye-tracking data. Their method involved minimizing a cost function, which included a data fidelity term, and the first and third order difference operator of the approximated signal. This is to obtain a signal that has the smooth and constant segments of eye-tracking data. They used ad hoc methods to set the value of regularization parameters, which determine how much weight the first and third order differences are given. This project proposes the use of Stein's unbiased risk estimator (SURE), an unbiased estimator of the mean squared error (MSE) of an unknown signal and an approximation of that signal, to dynamically set these regularization parameters to values that will attempt to minimize the MSE. Based on testing on signals of size 256 and 512, our SURE based approach performs better than many ad hoc methods. Further, our derivation of SURE for this cost function can be used for cost functions with any number of regularization terms. However, the variance of SURE compared to the true MSE seems to increase as more regularization terms are considered. Additionally, our proposed method can be costly, as SURE must be calculated for many different regularization parameter values in order to find the optimal one.

Project Supervisor: Ivan Selesnick (ECE)

Research Area: *Data Science/AI/Robotics*



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SURE-Based Parameter Selection for Denoising with Compound Sparse Regularizers

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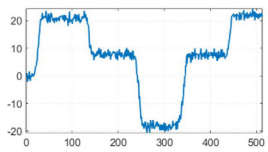
Abstract

- Removing noise from eye-tracking data can be important for studying neurological diseases.
- Eye-tracking data can be modeled as piecewise constant and quadratic, and its noise as white Gaussian noise.
- We propose a method of evaluating Stein's unbiased risk estimate (SURE), which is an estimate of the mean squared error (MSE), for denoised piecewise-constant-quadratic signals.
- SURE can be computed for multiple regularization parameter values, and the ones with the smallest SURE values used for an optimal denoising.

Background and Motivation

- Saccades are the brief eye movements that occur when looking from one visual target to another [1]. The analysis of these eye movements can be useful in studying some neurological disorders [2].
- The data generally consists of segments that are constants, when the eye is still, and segments that are quadratic, when the eye is moving.
- Noise is often present in this type of data, and it has been demonstrated that the noise can be modeled as white Gaussian noise [3]

Figure 1: Simulated noisy eye-tracking datas



- The success of any denoising attempt is contingent upon the selection of suitable regularization parameter values.

Proposed Method

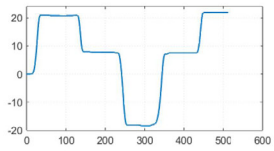
- Stein's unbiased risk estimate (SURE) is a statistical estimator of the mean squared error (MSE) between two signals.
- If trying to denoise a noisy signal, y, with noise of variance σ^2 , and the resulting signal is$\hat{x}$ while the original signal is x, SURE and the MSE are computed as follows [4].

$$SURE = \frac{1}{N}||\hat{x} - y||_2^2 + \frac{2\sigma^2}{N}Tr(J_y(\hat{x})) - \sigma^2$$

$$MSE = \frac{1}{N}||\hat{x} - x||_2^2$$

Results and Discussion

Figure 2: Denoised signal with proposed method.



- Our method successfully calculated suitable regularization parameters and produced a good denoising result.

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Acknowledgement

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

DATA SCIENCE/AI/ROBOTICS

UNAV: AN INFRASTRUCTURE-INDEPENDENT VISION-BASED NAVIGATION SYSTEM FOR PEOPLE WITH BLINDNESS AND LOW VISION

We present an innovative infrastructure-independent vision-based localization pipeline tailored for navigation assistance to end-users with blindness and low vision. It leverages computer vision algorithms and AI-driven image processing to offer real-time navigation support without relying on external sensors or GPS signals, making it versatile and accessible in various environments. Traditional navigation aids for the visually impaired often rely on fixed infrastructure, limiting their functionality to specific locations and dynamic environments. Our pipeline incorporates mapping, localization, and navigation. The application utilizes wayfinding to capture live video streams, with image recognition algorithms analyzing visual input to identify obstacles, pathways, and landmarks. This data is translated into audio feedback, providing users with audible cues and directional guidance. UNav's adaptability to different indoor and outdoor settings empowers users to confidently navigate complex spaces and unfamiliar locations. Through accuracy testing and user trials, UNav demonstrates its efficacy in improving mobility and spatial awareness, making it a transformative tool for enhancing independence and safety for individuals with blindness and low vision.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Anbang Yang

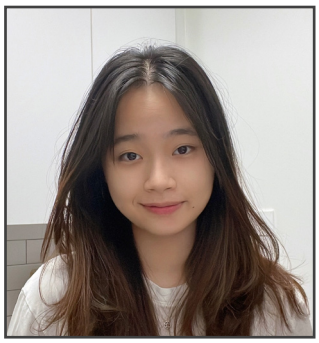
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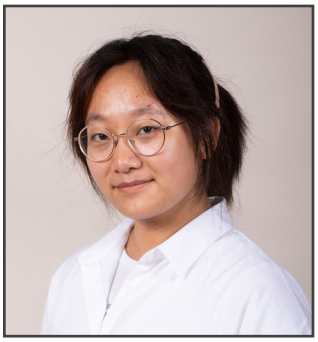
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UNav: An Infrastructure-Independent Vision-Based Navigation System for People with Blindness and Low Vision

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1. Computer Science, NYU Tandon 2. Computer Science, NYU Shanghai 3. Computer Engineering, NYU Tandon 4. Computer Science, NYU CAS, 5. Supervisor, NYU Tandon

Abstract

Leveraging computer vision algorithms and AI-driven image processing, UNav provides real-time navigation assistance by capturing live video streams for wayfinding, utilizing image recognition algorithms to identify obstacles, pathways, and landmarks. Our research includes accuracy testing and user trials, demonstrating UNav's efficacy in enhancing mobility and spatial awareness, making it a transformative tool for improving independence and safety for individuals with blindness and low vision.

Background on the Project

Recent technological advancements offer novel assistive tools for the visually impaired. A prime focus is indoor localization using computer vision, significantly enhancing guidance within indoor spaces [1]. Techniques leveraging WiFi Channel State Information can achieve decimeter-level indoor accuracy [2]. Moreover, the integration of fuzzy logic in indoor systems offers enhanced navigation for the visually impaired [3]. Vision-based localization techniques are pivotal for autonomous navigation [4], benefiting from the infusion of heterogeneous data [5].

The blend of semantic insights and localization methodologies offers improved robustness, crucial for large-scale applications [6].

Mapping and Accuracy Testing

To test our system, volunteers would travel with a GoPro attached to their backpack or helmet. The 360 images collected from the GoPro will then be used to map using OpenVSLAM, an open-source mapping technology.

The slam data is then analyzed to calculate the Dijsktra's shortest path to the destination along with the rotational and translational error. Once we successfully map a building's floor, we are able to test our system to see how well a user can interact with it.

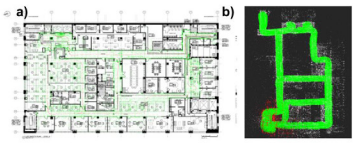


Figure 1: *a) Slam data aligned onto floor plan of Lighthouse Guild 6th floor b) Generated data from OpenVSLAM*

Test Results

Recently we have performed user trials at the LightHouse Guild Eyecare Facility. Results indicated that with ideal video quality (the highest resolution tested was 2880p), the device is capable of generating very precise navigation instructions with error as low as 2 cm.

In previous trials performed in Thailand, since we are working with Mahidol University, we had users walk a route without using our device (passive mode), and we had users walk using our device (active mode). Our data from our trials in Thailand show that our device improved walking time by 81%.

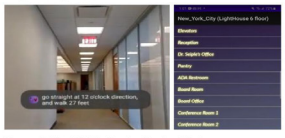


Figure 2*: Our Mobile Device During Trial*

Future Work

We are working on a new Agnostic Visual Place Recognition model that can perform well regardless of video resolution to ensure seamless user experience.

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Acknowledgement

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

USING TEXT INFORMATION FOR VIDEO VPR VS IMAGE VPR

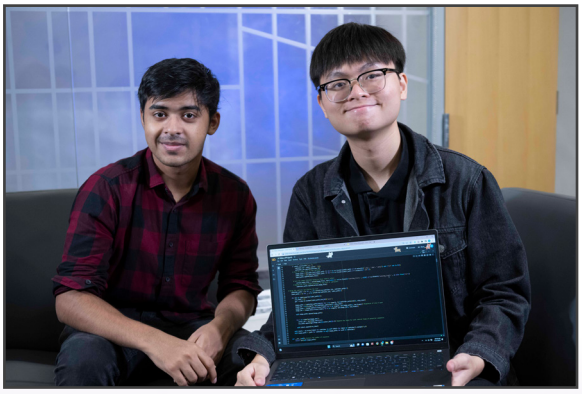
Visual Place Recognition (VPR) in machine learning is the task of identifying and recognizing locations that have already been seen previously. Previously there has been exploration of several techniques to enhance progress in this task. One of these being using sequences, instead of static images to utilize the inherently wider spectrum of spatial information. In this project, we introduce a new feature description for images/sequences of the locations. We leverage the capabilities of Vision-Language Models (VLMs) to extract textual information and meaningful data from a given scene, thereby transforming intricate visual data into an understandable textual format. This textual data is further processed by an advanced Language Model (LM), designed to parse, organize, and distill the most relevant information into a coherent, informative paragraph. By condensing the rich visual data into its most informative textual essence, the pipeline effectively reduces computational complexity and bolsters the subsequent processing stages. The text-based information is then passed to a Vector Embedding Model, which generates corresponding feature vectors for each image. These high-dimensional embeddings encapsulate the semantic and contextual characteristics of the visual environment, providing a robust representation less sensitive to varying conditions commonly encountered in VPR, such as lighting changes, seasonal variations, and view-point alterations. Through this approach, our pipeline offers an innovative method for improving the accuracy and efficiency of Visual Place Recognition tasks, highlighting the potent synergy between Vision-Language Models and Vector Embeddings in image and video understanding.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Chao Chen

Research Area: *Data Science/AI/Robotics*



Sneheel Sarangi
Computer Science, B.S., 2024
NYU Abu Dhabi



Sneheel Sarangi and Phuc Nguyen

NYU TANDON SCHOOL OF ENGINEERING

Using Textual Scene Information For VPR

Sneheel Sarangi

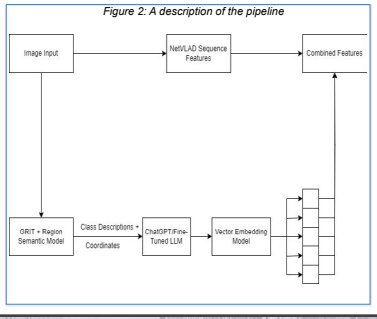
Abstract

Previously there has been exploration of several techniques to further progress on the Visual Place Recognition (VPR) task. We introduce a new feature description for images/sequences of the locations that leverages the capabilities of Vision-Language Models (VLMs) to extract textual information from a given scene. This textual data is further processed in a pipeline and converted to a feature vector for each inout image/sequence. These features encapsulate the semantic and contextual characteristics of the visual environment, providing a robust representation less sensitive to varying conditions commonly encountered in VPR, such as lighting changes, seasonal variations, and view-point alterations.

Background on the Project

VPR involves recognizing new scenes and matching them with pictures of the same scene in a pre-existing database accurately. Research in the field has previously taken several directions, however, the recent advances in using transformers for computer vision tasks, and rapid developments in large language models equip us with another tool to tackle the problem. Specifically, we take inspiration from the GRIT [1] model and use the ChatGPT API [2] for analysis.

Figure 2: A description of the pipeline



Methodology/Data

For this project, we use several different datasets to test our methods including the Oxford VPR [3] dataset, and the KITTI [4] dataset.

Our procedure involves first detecting objects and finding their coordinates using the GRIT model, passing this data to the ChatGPT API for an analysis, and then creating a vector embedding of this analysis which can be then used with the cosine similarity metric to find matches for a given query.

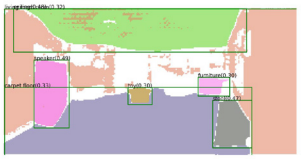
Conclusions

Our initial testing shows promising results with this method, though we are yet to conduct more rigorous tests to validate this. We intend to join these generated features to our original CNN based method- generated features and test the relative improvements.

Figure 2,3 Steps in our workflow



a black car parked in the street: [230, 57, 305, 101]; trees on the sidewalk: [1, 0, 152, 78]; a black car parked on the street: [90, 54, 140, 72]; a street scene in the city: [21, 3, 276, 113]; a person riding a motorcycle: [162, 54, 173, 69]; a row of trees: [178, 0, 267, 70];



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Acknowledgement

VIDEO VPR VERSUS IMAGE VPR

This research proposal aims to advance Visual Place Recognition (VPR) using deep networks by exploring a novel sequence-to-sequence approach. The main objective is to design and implement an algorithm capable of accurately recognizing places without relying on ground truth sensor poses for supervised learning. By drawing inspiration from successful projects like SeqMatchNet and SeqNet, the research aims to break away from traditional constraints and enhance the model's accuracy and robustness through a combination of sequence-to-sequence and image-to-image data matching. The outcomes will be validated through extensive experimentation on synthetic and real 3D datasets, with the goal of contributing impactful results to the field of VPR.

Project Supervisor: Chen Feng (CUE, CSE, MAE, CUSP); **Research Staff:** Chao Chen

Research Area: *Data Science/AI/Robotics*



Phuc Nguyen
Computer Science, B.S., 2027
NYU Abu Dhabi



Sneheel Sarangi and Phuc Nguyen

WAVELET TRANSFORM WITH TUNABLE Q FACTOR IN THE USE OF BASIS PURSUIT DENOISING

A major disadvantage of the Fourier Transform is it captures global frequency information, meaning frequencies that persist over an entire signal. This kind of signal decomposition may not serve all applications well (e.g. Electrocardiography (ECG) where signals have short intervals of characteristic oscillation). An alternative approach is the Wavelet Transform, which decomposes a function into a set of wavelets. Here, we mainly focus on a discrete time wavelet transform "TQWT" which is called wavelet transform with Tunable Q factor. Ideally, the Q factor of a wavelet transform should be chosen in part according to the oscillatory behavior of the signal to which it is applied. It can help us solve the basis pursuit denoising problem under the tune of Q factor and lambda parameters. And I have implemented an automatic algorithm to choose the regularization parameter, which utilizes the universal thresholding. In this way, we can get the regularization parameter according to the length of the signal wavelet transform to save the energy of tuning. In larger applications, we can put into use such as speech waveforms, ECG signals and so on.

Project Supervisor: Ivan Selesnick (ECE)

Research Area: *Data Science/AI/Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Wavelet transform with tunable Q factor in the use of basis pursuit denoising

Binxi Li

Abstract

A major disadvantage of the Fourier Transform is it captures *global* frequency information, meaning frequencies that persist over an entire signal. This kind of signal decomposition may not serve all applications well (e.g. Electrocardiography (ECG) where signals have short intervals of characteristic oscillation). An alternative approach is the Wavelet Transform, which decomposes a function into a set of wavelets.

Background

Here, we mainly focus on a discrete time wavelet transform "TQWT" which is called wavelet transform with Tunable Q factor. Ideally, the Q factor of a wavelet transform should be chosen in part according to the oscillatory behavior of the signal to which it is applied. It can help us solve the basis pursuit denoising problem under the tune of Q factor and lambda parameters. And I have implemented an automatic algorithm to choose the regularization parameter, which utilizes the universal thresholding.

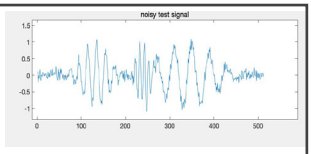
In this way, we can get the regularization parameter according to the length of the signal wavelet transform to save the energy of tuning.
In larger applications, we can put into use such as speech waveforms, ECG signals and so on.

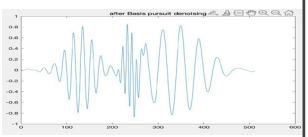
Test methods

We have tested the methods for real speech data and test data of the matlab itself. For speech data, we tested on both noisy environments and quiet environment, with both oscillatory signal and non-oscillatory signals.
Through different threshold methods, including hard threshold and soft threshold, we analyse the denoised signal in ocenstudio to see which method performs better.

Future work

Not only for audio signal processing and speech analysis, but also for biomedical signal analysis, financial signal analysis and seismic data analysis.





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Acknowlegdement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. I would also like to thank my professor Ivan W Selesnick for all his guidance and mentorship throughout the course of this program.

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.

FACULTY

Reginé Gilbert (TCS)
Dzung Luong (MAE)
Nikita Grigoryev (CBE)



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EXPLORING VIRTUAL EDUCATIONAL ENVIRONMENT: NYU'S MAKERSPACE

This research project explores the implementation and benefits of a metaverse platform and mixed-reality technologies to create a virtual educational environment. The goal is to provide students with inclusive and flexible learning opportunities, allowing access to online resources and interaction with peers and instructors through various devices–from smartphones to desktops. The project arose from literature reviews that showcased the growing demand for immersive learning experiences in education. Given virtual reality's success in enhancing student engagement, motivation, and knowledge retention, efforts to integrate metaverse technologies into more diverse settings–including industry training–have been advancing. One of the primary research objectives was to develop a realistic 3D model of NYU's MakerSpace within a metaverse platform. In this model, the user virtually gets training to use the several pieces of equipment that are available in the physical lab.

Project Supervisor: Dzung Luong (MAE)

Research Areas: *Emerging Media, Urban*



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GLASS Fellow

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Metaverse For Education

Tina Chibane, Jason Mai, Nabiha Siddique

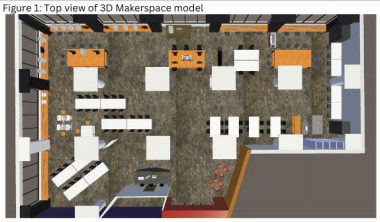
Abstract

This research project explores the implementation and benefits of a metaverse platform and mixed-reality technologies to create a virtual educational environment. The goal is to provide students with inclusive and flexible learning opportunities, allowing access to online resources and interaction with peers and instructors through various devices. The project arose from literature reviews that showcased the growing demand for immersive learning experiences in education. Given virtual reality's success in enhancing student engagement, motivation, and knowledge retention, efforts to integrate metaverse technologies into more diverse settings have been advancing. One of the primary research objectives was to develop a realistic 3D model of NYU's MakerSpace within a metaverse platform. In this model, the user virtually gets training to use the several pieces of equipment that are available in the physical lab.

Background on Project

Virtual reality (VR) has emerged as a powerful technology with great potential for revolutionizing education. By immersing users in computer-generated environments, VR offers unique and engaging learning experiences that traditional methods cannot replicate. Despite its promising potential, there are challenges to implementing VR in education. Cost, content creation, and the need for suitable hardware and training for educators are some of the barriers. However, as technology advances and becomes more affordable, VR is likely to play an increasingly significant role in shaping the future of education.

Figure 1: Top view of 3D Makerspace model



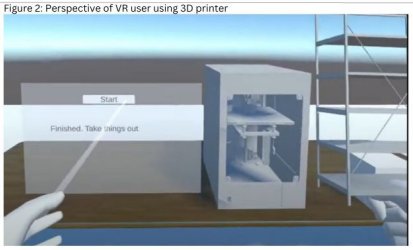
Test Environment

The Makerspace was a perfect environment for a 3D model because it is an educational and interactive space that reflects what this research seeks in a virtual environment. Unity was used to develop the 3D environment because the user-friendly platform allows users to easily design with realistic physics simulation and engaging mechanics. Users can also engage with each other due to the multiplayer functions provided by Photon Unit Networking.

Relevance

Metaverse technologies have enhanced learning in both academic and industrial contexts by improving student engagement and knowledge retention. And with the addition of multi-player features to virtual classrooms, students and instructors can collaborate beyond physical limitations, making learning more accessible and interactive. Therefore, the implementation of virtual reality platforms in education serves as a vehicle to foster meaningful interactions and promote student engagement in hybrid classrooms.

Figure 2: Perspective of VR user using 3D printer



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 and GLASS fellowships.

FORMULATING INCLUSIVE AND ACCESSIBLE HEURISTICS: A DEVELOPMENTAL APPROACH

Extended reality (XR) technologies like virtual, augmented, and mixed reality are becoming more prevalent, but many XR experiences are not designed with accessibility in mind. Existing accessibility heuristics are not tailored for XR and can be difficult for developers and designers with tight deadlines to implement. There is also limited research on the needs of users with disabilities in XR spaces. This research aims to define new heuristics to enhance accessibility in XR experiences.

Valuable insights were gathered through discussions with fellow researchers in the accessibility and spatial computing domains during various conferences and panel discussions. To gain a deeper understanding, we encompassed an extensive literature review focused on accessibility, XR (Extended Reality), and human-computer interaction and examined sample XR experiences, which shed light on existing heuristic limitations. Accessibility tip cards were designed to provide concise guidance for developers and designers. Co-design sessions with people with disabilities ensured the heuristics met user needs.

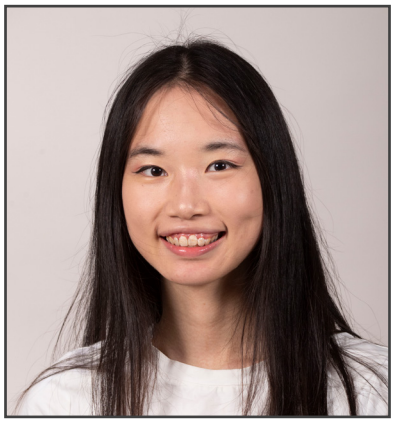
The key contents were implementing, creating, and testing an updated set of evidence-based accessibility heuristics for XR. The heuristics would integrate guidance in designing vision, mobility, cognition, and speech. This research aims at providing designers, developers, and researchers with practical heuristics to evaluate and improve the accessibility of virtual, augmented, and mixed-reality experiences in order to promote a more inclusive XR space for people with disabilities.

Project Supervisor: Reginé Gilbert (TCS); **Other Collaborators:** Janvi Jignesh Patel, Spandita Sarmah

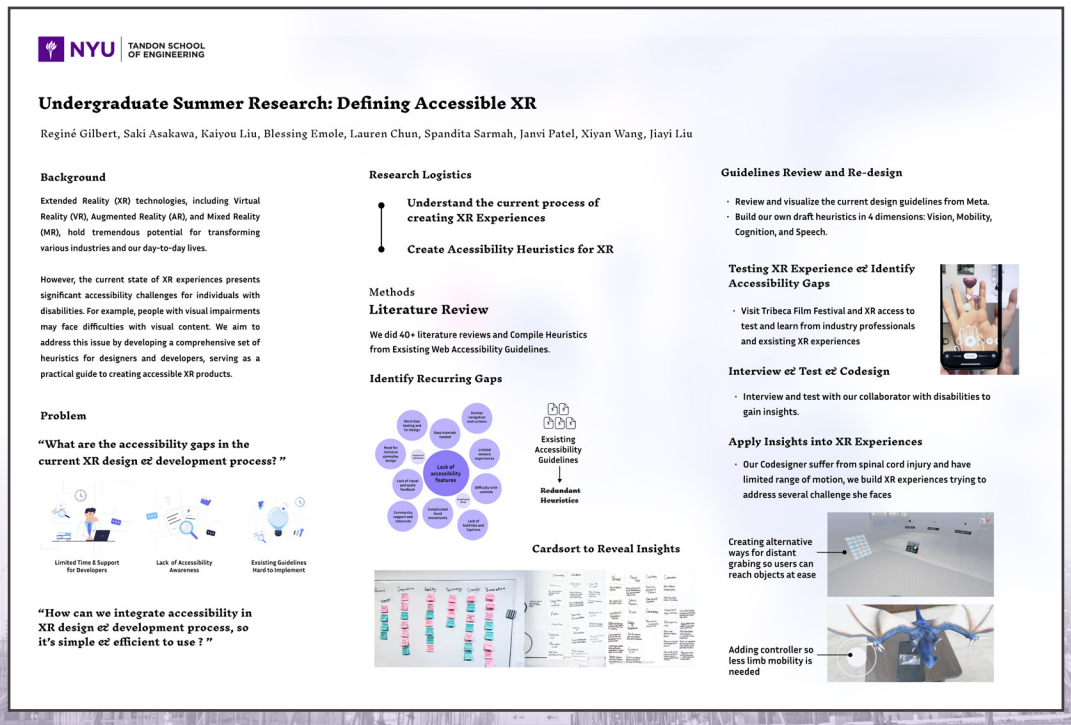
Research Area: *Emerging Media*



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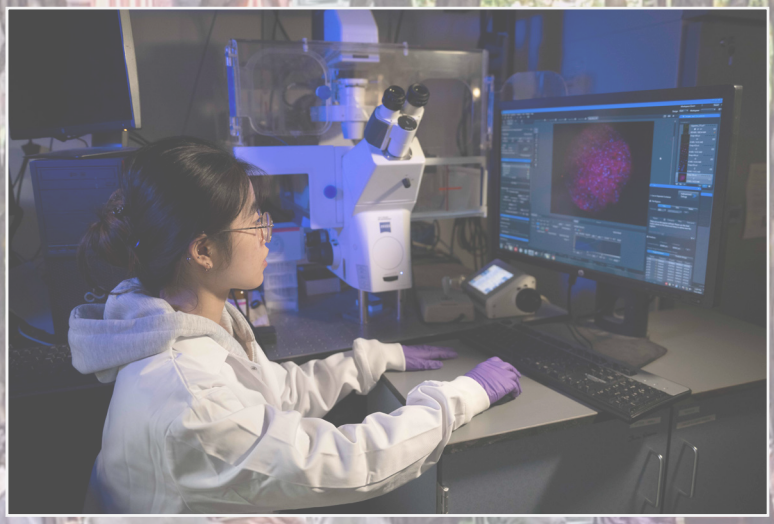


HEALTH

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.

FACULTY

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David Truong (BME)



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ACCESSING BACTERIAL TRANSFORMATION OF SOLAR IRRADIATED AMPR-CONTAINING PUC19 PLASMID

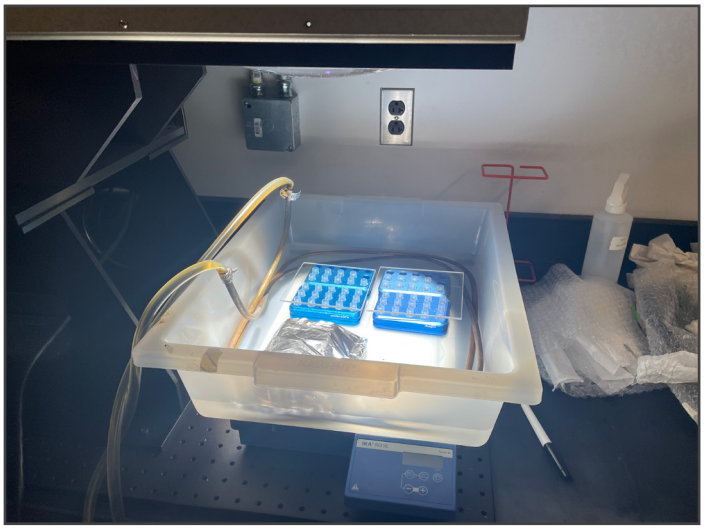
Antibiotic resistance genes (ARGs) are becoming more prevalent in natural water systems through agricultural runoff, insufficient wastewater treatment, and improper medicinal disposal. Through horizontal gene transfer, ARGs can undergo bacterial transformation making bacteria resistant to antibiotics. According to the US CDC, antibiotic-resistant infections and deaths are increasing each year. Therefore, understanding the persistence of ARGs in the environment is crucial. ARGs can degrade in sunlit waters through direct and indirect photolysis. Direct photolysis damages DNA as photons are absorbed and dimerization-inducing photoproducts are formed. Indirect photolysis damages DNA as photons are absorbed by photosensitizers (i.e., dyes, organic matter, chemicals, etc.) and photochemically produced reactive intermediates (PPRI) are formed. The goal of the research is to analyze and evaluate the decay of the ampicillin-resistant gene, ampR, due to sunlight photolysis through bacterial transformation. Plasmid damage due to sunlight could lead to loss of gene function or inability for bacterial uptake, so experiments were designed to understand the extent of both outcomes. Preliminary results show a 2-log loss of ampR transformation efficiency after 72 hours of full spectrum sunlight exposure in photosensitizer-free and photosensitizer-present solutions.

Project Supervisor: Andrea Silverman (CUE); **Research Staff:** Alma Rocha, Mwale Chiyenge

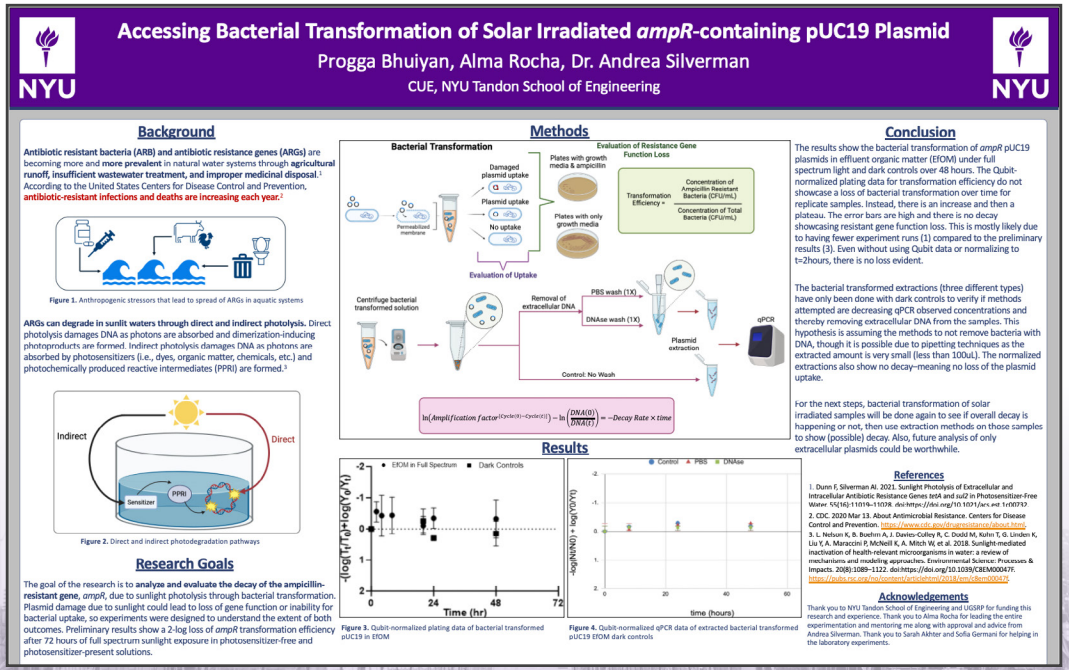
Research Areas: *Health, Sustainability*



Progga Bhuiyan
Chemical and Biomolecular Engineering, B.S., 2024
NYU Tandon School of Engineering



Solar simulation setup for ampR-containing pUC19 plasmids



APPENDING VIRAL INFILTRATION TAGS ONTO SUPERCHARGED COILED-COIL PROTEINS TO EMPOWER ENDOSOMAL ESCAPE

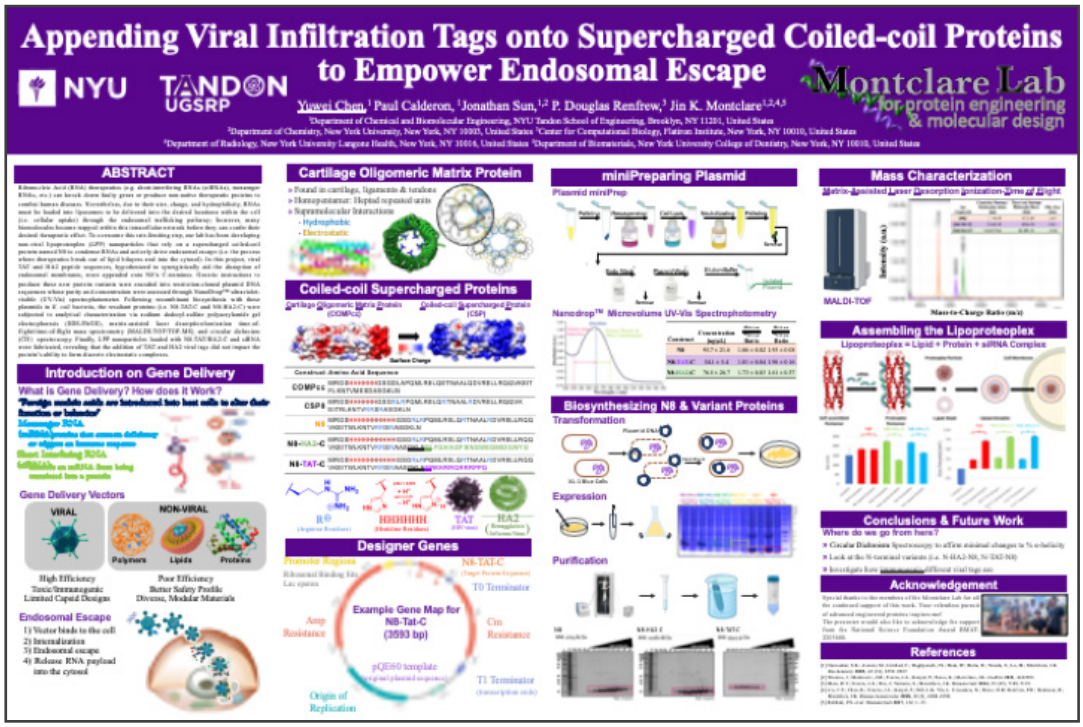
Ribonucleic Acid (RNA) therapeutics (e.g. short-interfering RNAs (siRNAs), messenger RNAs, etc.) can knock down faulty genes or produce non-native therapeutic proteins to combat human diseases. Nevertheless, due to their size, charge, and hydrophilicity, RNAs must be loaded into liposomes to be delivered into the desired locations within the cell (i.e. cellular uptake) through the endosomal trafficking pathway; however, many biomolecules become trapped within this intracellular network before they can confer their desired therapeutic effect. To overcome this rate-limiting step, our lab has been developing non-viral lipoproteoplex (LPP) nanoparticles that rely on a supercharged coiled-coil protein named N8 to condense RNAs and actively drive endosomal escape (i.e. the process where therapeutics break out of lipid bilayers and into the cytosol). In this project, viral TAT and HA2 peptide sequences, hypothesized to synergistically aid the disruption of endosomal membranes, were appended onto N8's C-terminus. Genetic instructions to produce these new protein variants were encoded into restriction-cloned plasmid DNA sequences whose purity and concentration were assessed through NanoDropTM ultraviolet-visible (UV-Vis) spectrophotometer. Following recombinant biosynthesis with these plasmids in E. coli bacteria, the resultant proteins (i.e. N8-TAT-C and N8-HA2-C) were subjected to analytical characterization via sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE), matrix-assisted laser desorption/ionization time-of-flight/time-of-flight mass spectrometry (MALDI-TOF/TOF-MS), and circular dichroism (CD) spectroscopy. Finally, LPP nanoparticles loaded with N8-TAT/HA2-C and siRNA were fabricated, revealing that the addition of TAT and HA2 viral tags did not impact the protein's ability to form discrete electrostatic complexes.

Project Supervisor: Jin Montclare (CBE); **Other Collaborators:** Jonathan W. Sun, Douglas Renfrew

Research Area: *Health*



Yuwei Chen
Biomolecular Science, B.S., 2026
NYU Tandon School of Engineering



AT-HOME IRON LEVEL DETECTION USING SALIVARY FERRITIN

The problem of iron deficiency anemia is very prevalent around the world, affecting close to 25% of the global population and most heavily those of lower socioeconomic status (StatPearls). Currently, iron levels are most commonly detected by labs testing blood samples from patients. The necessity of doctor's visits and labs can be expensive and time consuming. In addition, drawing blood is a painful and dangerous process for people with iron deficiency anemia since blood loss results in lower iron levels in the body. We're creating a non-invasive method to measure iron levels by detecting salivary ferritin, a protein that stores iron, using a peptide aptamer. Our goal is to create an electronic, inexpensive biosensor in which a peptide aptamer detects and binds to ferritin in saliva, emitting a fluorescent signal proportional to the concentration of the ferritin analyte. This is then read by an Arduino sensor that prepares the fluorescent signal to be displayed on a user interpretation system that can generate iron level results that the user can understand. Our aptamer consists of the peptide sequence at the binding site between cleaved high molecular weight kininogen (HKa) and ferritin. There are studies showing this peptide's high binding affinity with ferritin, and we confirmed this using AutoDock Vina (a protein-ligand computational docking tool). We now plan to use a direct ELISA with streptavidin-biotin detection to further test this ligand binding affinity before creating the device. A more long-term goal is to make this device capable of testing various iron level markers, as just ferritin levels aren't enough to replace doctor's visits and CBC panels.

Project Supervisor: Jin Ryoun Kim (CBE)

Research Areas: *Health, Sustainability*



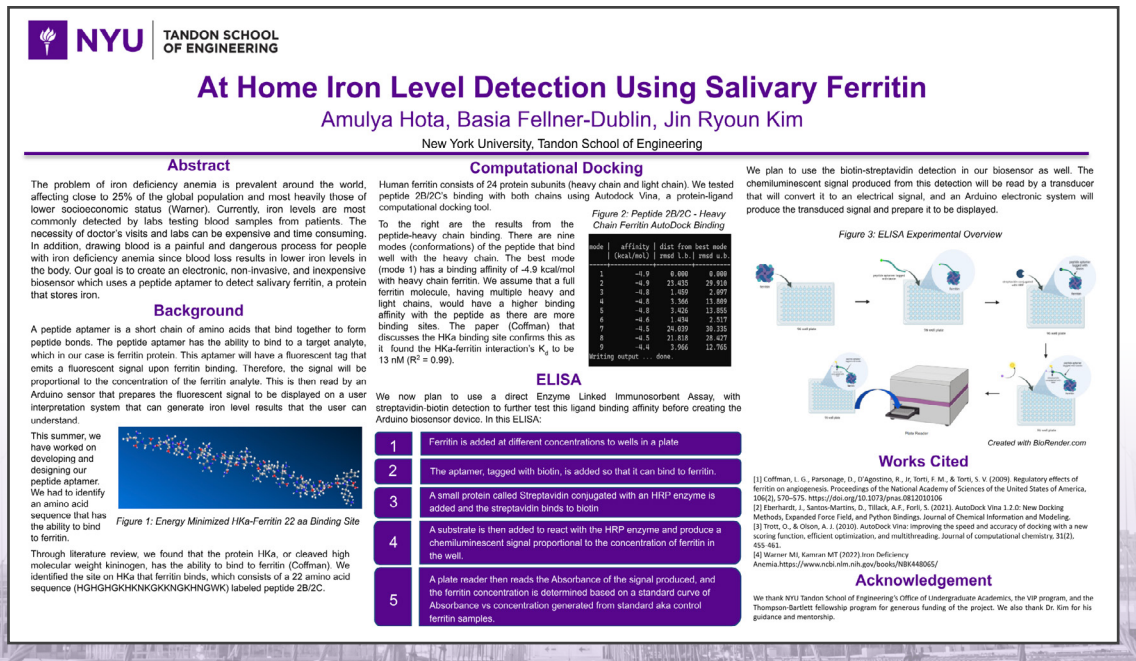
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NYU Tandon School of Engineering

Thompson-Bartlett Fellow



NYU TANDON SCHOOL OF ENGINEERING

At Home Iron Level Detection Using Salivary Ferritin

Amulya Hota, Basia Fellner-Dublin, Jin Ryoun Kim

New York University, Tandon School of Engineering

Abstract

The problem of iron deficiency anemia is prevalent around the world, affecting close to 25% of the global population and most heavily those of lower socioeconomic status (Warner). Currently, iron levels are most commonly detected by labs testing blood samples from patients. The necessity of doctor's visits and labs can be expensive and time consuming. In addition, drawing blood is a painful and dangerous process for people with iron deficiency anemia since blood loss results in lower iron levels in the body. Our goal is to create an electronic, non-invasive, and inexpensive biosensor which uses a peptide aptamer to detect salivary ferritin, a protein that stores iron.

Background

A peptide aptamer is a short chain of amino acids that bind together to form peptide bonds. The peptide aptamer has the ability to bind to a target analyte, which in our case is ferritin protein. This aptamer will have a fluorescent tag that emits a fluorescent signal upon ferritin binding. Therefore, the signal will be proportional to the concentration of the ferritin analyte. This is then read by an Arduino sensor that prepares the fluorescent signal to be displayed on a user interpretation system that can generate iron level results that the user can understand.

This summer, we have worked on developing and designing our peptide aptamer. We had to identify an amino acid sequence that has the ability to bind to ferritin.

Figure 1: Energy Minimized HKa-Ferritin 22 aa Binding Site

Through literature review, we found that the protein HKa, or cleaved high molecular weight kininogen, has the ability to bind to ferritin (Coffman). We identified the site on HKa that ferritin binds, which consists of a 22 amino acid sequence (HGHGHGKHKNKGKKNGKHNGWK) labeled peptide 2B/2C.

Computational Docking

Human ferritin consists of 24 protein subunits (heavy chain and light chain). We tested peptide 2B/2C's binding with both chains using Autodock Vina, a protein-ligand computational docking tool.

To the right are the results from the peptide-heavy chain binding. There are nine modes (conformations) of the peptide that bind well with the heavy chain. The best mode (mode 1) has a binding affinity of -4.9 kcal/mol with heavy chain ferritin. We assume that a full ferritin molecule, having multiple heavy and light chains, would have a higher binding affinity with the peptide as there are more binding sites. The paper (Coffman) that discusses the HKa binding site confirms this as it found the HKa-ferritin interaction's K_d to be 13 nM (R^2 = 0.99).

Figure 2: Peptide 2B/2C - Heavy Chain Ferritin AutoDock Binding

mode	affinity (kcal/mol)	dist from best mode l.b.	dist from best mode u.b.
1	-4.9	0.000	0.000
2	-4.9	25.435	29.910
3	-4.8	1.659	2.897
4	-4.8	3.566	13.869
5	-4.8	3.426	13.855
6	-4.6	1.434	2.517
7	-4.5	26.639	30.735
8	-4.5	21.818	28.427
9	-4.4	3.966	12.765

Writing output ... done.

ELISA

We now plan to use a direct Enzyme Linked Immunosorbent Assay, with streptavidin-biotin detection to further test this ligand binding affinity before creating the Arduino biosensor device. In this ELISA:

1. Ferritin is added at different concentrations to wells in a plate
2. The aptamer, tagged with biotin, is added so that it can bind to ferritin.
3. A small protein called Streptavidin conjugated with an HRP enzyme is added and the streptavidin binds to biotin
4. A substrate is then added to react with the HRP enzyme and produce a chemiluminescent signal proportional to the concentration of ferritin in the well.
5. A plate reader then reads the Absorbance of the signal produced, and the ferritin concentration is determined based on a standard curve of Absorbance vs concentration generated from standard aka control ferritin samples.

We plan to use the biotin-streptavidin detection in our biosensor as well. The chemiluminescent signal produced from this detection will be read by a transducer that will convert it to an electrical signal, and an Arduino electronic system will produce the transduced signal and prepare it to be displayed.

Figure 3: ELISA Experimental Overview

Created with BioRender.com

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Acknowledgement

We thank NYU Tandon School of Engineering's Office of Undergraduate Academics, the VIP program, and the Thompson-Bartlett fellowship program for generous funding of the project. We also thank Dr. Kim for his guidance and mentorship.

BIOSENSORS FOR DRUG DISCOVERY

Through the eventual utilization of optical sensor technology, this project aims to analyze the colloidal aggregation of small molecules, in the hopes of developing high throughput methods for screening drug lead compounds as well as for monitoring formation of biomacromolecular complexes. The sensors use optical resonators and light waveguides to sensitively measure changes in refractive index that can be correlated to presence of the colloidal molecular aggregates or biomolecular binding. For example, if a protein is attached to the sensor, selective binding of bioactive molecules to the protein can be observed, allowing for determination of whether the molecules have therapeutic promise. An important confounding factor, however, is that such drug candidate molecules often form large aggregates which cause a false binding signal due to non-specific interactions with proteins. Current methods require that a second assay is run by adding an aggregate-preventing detergent, to better determine if true binding was observed. Our project uses spectroscopic methods to determine the rate at which aggregates form from model small molecule drugs, as well as the size of the aggregates, so that these compounds can then be used to test the optical sensor being developed for high throughput screening, without the need for additional experiments using detergents or other steps. The sensor signals can instead be carefully analyzed to identify aggregate presence from transient flyby events or from direct attachment of the aggregates to the sensor, thus shedding light on whether a compound truly exhibits specific molecular binding to the target proteins.

Project Supervisor: Rastislav Levicky (CBE)

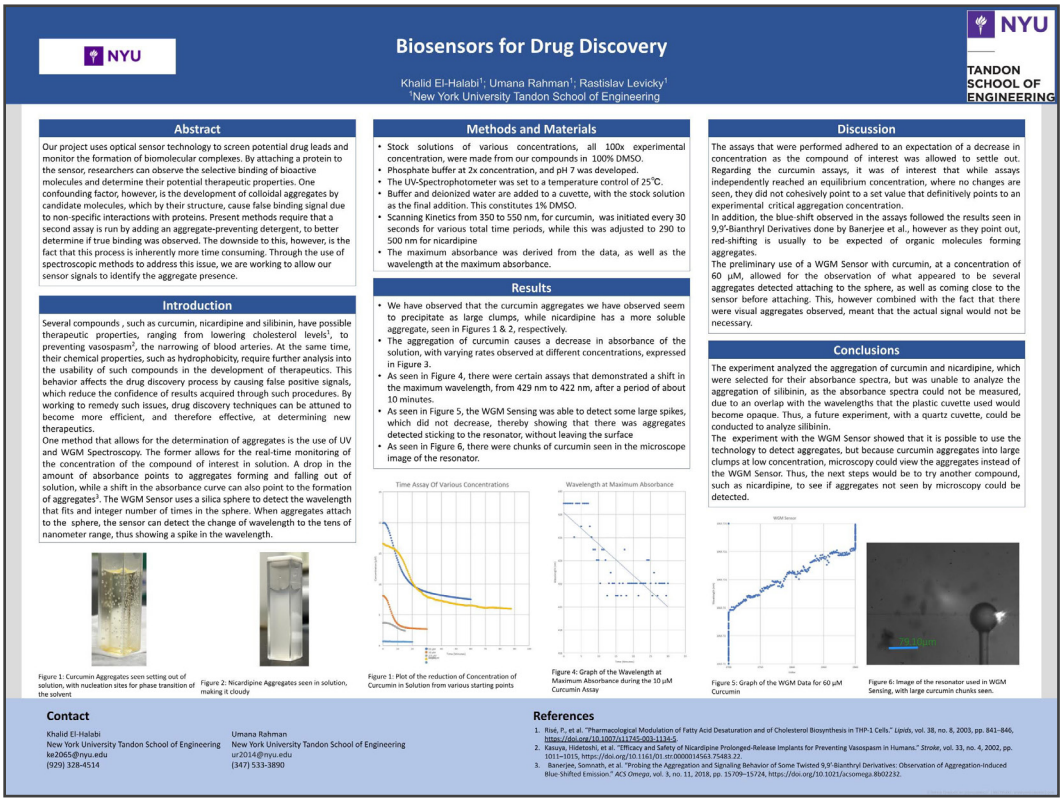
Research Area: *Health*



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NYU

Biosensors for Drug Discovery

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NYU TANDON SCHOOL OF ENGINEERING

Abstract

Our project uses optical sensor technology to screen potential drug leads and monitor the formation of biomolecular complexes. By attaching a protein to the sensor, researchers can observe the selective binding of bioactive molecules and determine their potential therapeutic properties. One confounding factor, however, is the development of colloidal aggregates by candidate molecules, which by their structure, cause false binding signal due to non-specific interactions with proteins. Present methods require that a second assay is run by adding an aggregate-preventing detergent, to better determine if true binding was observed. The downside to this, however, is the fact that this process is inherently more time consuming. Through the use of spectroscopic methods to address this issue, we are working to allow our sensor signals to identify the aggregate presence.

Introduction

Several compounds , such as curcumin, nicardipine and silibinin, have possible therapeutic properties, ranging from lowering cholesterol levels[1], to preventing vasospasm[2], the narrowing of blood arteries. At the same time, their chemical properties, such as hydrophobicity, require further analysis into the usability of such compounds in the development of therapeutics. This behavior affects the drug discovery process by causing false positive signals, which reduce the confidence of results acquired through such procedures. By working to remedy such issues, drug discovery techniques can be attuned to become more efficient, and therefore effective, at determining new therapeutics.
One method that allows for the determination of aggregates is the use of UV and WGM Spectroscopy. The former allows for the real-time monitoring of the concentration of the compound of interest in solution. A drop in the amount of absorbance points to aggregates forming and falling out of solution, while a shift in the absorbance curve can also point to the formation of aggregates[3]. The WGM Sensor uses a silica sphere to detect the wavelength that fits and integer number of times in the sphere. When aggregates attach to the sphere, the sensor can detect the change of wavelength to the tens of nanometer range, thus showing a spike in the wavelength.

Methods and Materials

- Stock solutions of various concentrations, all 100x experimental concentration, were made from our compounds in 100% DMSO.
- Phosphate buffer at 2x concentration, and pH 7 was developed.
- The UV-Spectrophotometer was set to a temperature control of 25°C.
- Buffer and deionized water are added to a cuvette, with the stock solution as the final addition. This constitutes 1% DMSO.
- Scanning Kinetics from 350 to 550 nm, for curcumin, was initiated every 30 seconds for various total time periods, while this was adjusted to 290 to 500 nm for nicardipine
- The maximum absorbance was derived from the data, as well as the wavelength at the maximum absorbance.

Results

- We have observed that the curcumin aggregates we have observed seem to precipitate as large clumps, while nicardipine has a more soluble aggregate, seen in Figures 1 & 2, respectively.
- The aggregation of curcumin causes a decrease in absorbance of the solution, with varying rates observed at different concentrations, expressed in Figure 3.
- As seen in Figure 4, there were certain assays that demonstrated a shift in the maximum wavelength, from 429 nm to 422 nm, after a period of about 10 minutes.
- As seen in Figure 5, the WGM Sensing was able to detect some large spikes, which did not decrease, thereby showing that there was aggregates detected sticking to the resonator, without leaving the surface
- As seen in Figure 6, there were chunks of curcumin seen in the microscope image of the resonator.

Discussion

The assays that were performed adhered to an expectation of a decrease in concentration as the compound of interest was allowed to settle out. Regarding the curcumin assays, it was of interest that while assays independently reached an equilibrium concentration, where no changes are seen, they did not cohesively point to a set value that definitively points to an experimental critical aggregation concentration.
In addition, the blue-shift observed in the assays followed the results seen in 9,9'-Bianthryl Derivatives done by Banerjee et al., however as they point out, red-shifting is usually to be expected of organic molecules forming aggregates.
The preliminary use of a WGM Sensor with curcumin, at a concentration of 60 μM, allowed for the observation of what appeared to be several aggregates detected attaching to the sphere, as well as coming close to the sensor before attaching. This, however combined with the fact that there were visual aggregates observed, meant that the actual signal would not be necessary.

Conclusions

The experiment analyzed the aggregation of curcumin and nicardipine, which were selected for their absorbance spectra, but was unable to analyze the aggregation of silibinin, as the absorbance spectra could not be measured, due to an overlap with the wavelengths that the plastic cuvette used would become opaque. Thus, a future experiment, with a quartz cuvette, could be conducted to analyze silibinin.
The experiment with the WGM Sensor showed that it is possible to use the technology to detect aggregates, but because curcumin aggregates into large clumps at low concentration, microscopy could view the aggregates instead of the WGM Sensor. Thus, the next steps would be to try another compound, such as nicardipine, to see if aggregates not seen by microscopy could be detected.

Figure 1: Curcumin Aggregates seen setting out of solution, with nucleation sites for phase transition of the solvent

Figure 2: Nicardipine Aggregates seen in solution, making it cloudy

Figure 1: Plot of the reduction of Concentration of Curcumin in Solution from various starting points

Figure 4: Graph of the Wavelength at Maximum Absorbance during the 10 μM Curcumin Assay

Figure 5: Graph of the WGM Data for 60 μM Curcumin

Figure 6: Image of the resonator used in WGM Sensing, with large curcumin chunks seen.

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DEVELOPING IMMUNOTHERAPY SCREENING PLATFORM USING 'CAR-T-ON-A-CHIP' MODEL

Immunotherapy has allowed the opportunity to strengthen a patient's immune system to attack tumors resulting in the potential reduction or eradication of tumors. One specific immunotherapy, called CAR T-cell therapy, can combat cancer by receiving patient T cells and modifying them into CAR T cells that can recognize and bind to the cancer cells resulting in removal of cancer cells. Though there is a short-term remission and a high rate of relapse from this treatment., we need a platform to be able to study and improve CAR T-cell therapy. Microfluidic Organ-On-A-Chip is a valuable platform that will give scientists the ability to study both normal or disease relevant tissue function, as it has great precision with high throughput while emulating key physiological functional units of an organ or organ system. Thus, the objective is to engineer an organotypic CAR T- cell model which can mimic the microenvironment of the human bone marrow niche. In order to test the microfluidic chip, we monitored for CAR T functional dynamics with confocal microscopy, there was a greater proportion of expression of activation markers in CAR-T cells compared to the mock T cells, which is consistent with what is expected to happen in vivo during CAR T therapy. 'CAR-T-on-a-chip' model can potentially allow researchers to develop immunotherapy that is personalized to the patient. Overall, by creating a platform to test immunotherapy strategies for CAR-T cells, we can improve patient response to cancer.

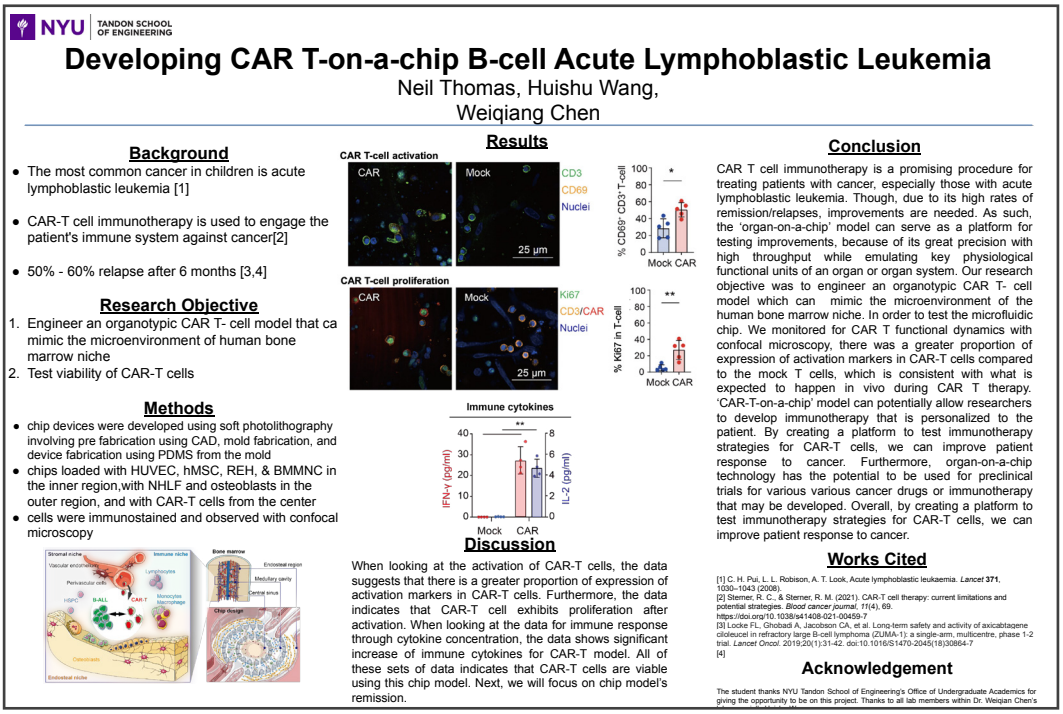
Project Supervisor: Weiqiang Chen (BME, MAE); **Research Staff:** Lunan Liu, Huishu Wang; **Other Collaborators:** Brendon Jing, Hannah Chen

Research Area: *Health*



Neil Thomas
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University of Texas at Austin

Visiting Student Fellow



NYU TANDON SCHOOL OF ENGINEERING

Developing CAR T-on-a-chip B-cell Acute Lymphoblastic Leukemia

Neil Thomas, Huishu Wang, Weiqiang Chen

Background

- The most common cancer in children is acute lymphoblastic leukemia [1]
- CAR-T cell immunotherapy is used to engage the patient's immune system against cancer[2]
- 50% - 60% relapse after 6 months [3,4]

Research Objective

1. Engineer an organotypic CAR T- cell model that ca mimic the microenvironment of human bone marrow niche
2. Test viability of CAR-T cells

Methods

- chip devices were developed using soft photolithography involving pre fabrication using CAD, mold fabrication, and device fabrication using PDMS from the mold
- chips loaded with HUVEC, hMSC, REH, & BMMNC in the inner region,with NHLF and osteoblasts in the outer region, and with CAR-T cells from the center
- cells were immunostained and observed with confocal microscopy

Results

Discussion

When looking at the activation of CAR-T cells, the data suggests that there is a greater proportion of expression of activation markers in CAR-T cells. Furthermore, the data indicates that CAR-T cell exhibits proliferation after activation. When looking at the data for immune response through cytokine concentration, the data shows significant increase of immune cytokines for CAR-T model. All of these sets of data indicates that CAR-T cells are viable using this chip model. Next, we will focus on chip model's remission.

Conclusion

CAR T cell immunotherapy is a promising procedure for treating patients with cancer, especially those with acute lymphoblastic leukemia. Though, due to its high rates of remission/relapses, improvements are needed. As such, the 'organ-on-a-chip' model can serve as a platform for testing improvements, because of its great precision with high throughput while emulating key physiological functional units of an organ or organ system. Our research objective was to engineer an organotypic CAR T- cell model which can mimic the microenvironment of the human bone marrow niche. In order to test the microfluidic chip. We monitored for CAR T functional dynamics with confocal microscopy, there was a greater proportion of expression of activation markers in CAR-T cells compared to the mock T cells, which is consistent with what is expected to happen in vivo during CAR T therapy. 'CAR-T-on-a-chip' model can potentially allow researchers to develop immunotherapy that is personalized to the patient. By creating a platform to test immunotherapy strategies for CAR-T cells, we can improve patient response to cancer. Furthermore, organ-on-a-chip technology has the potential to be used for preclinical trials for various various cancer drugs or immunotherapy that may be developed. Overall, by creating a platform to test immunotherapy strategies for CAR-T cells, we can improve patient response to cancer.

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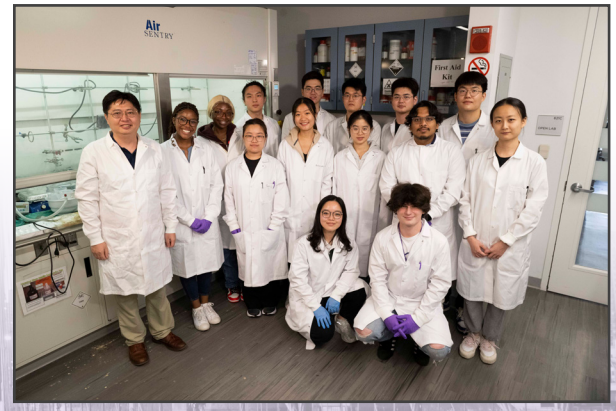
Acknowledgement

The student thanks NYU Tandon School of Engineering's Office of Undergraduate Academics for giving the opportunity to be on this project. Thanks to all lab members within Dr. Weiqian Chen's

Neil Thomas uses the cell culture hood



Professor Chen's Lab. *From Left to Right:* Professor Chen, Sandra, Djamila, Brandon, Lunan, Fanghao, Chao, Shuhao, Sue, Hannah, Jingwei, Neil, Huishu, Kate, Milo



DIGITAL HEALTHCARE APPLICATIONS FOR MULTIPLE SCLEROSIS REHABILITATION

Multiple Sclerosis (MS) is a chronic, autoimmune, and inflammatory disease of the Central Nervous System. It is widely prevalent, affecting 2.8 million people worldwide and more than 900,000 in the US alone. Walking impairment is the disease's most frequent and debilitating symptom, so monitoring symptoms and being physically active are significant in MS self-management. Therefore, there is a desire to use wearable sensors and AI to create a more personalized and targeted treatment plan for patients with regard to everyday activities. In addition, these digital technologies will aid in early detection and intervention of the disease. This research explores the importance and impact of digital technologies in the self-management of MS through the design and evaluation of an intuitive mobile app combined with a wearable sensor for remote patient monitoring. The sensors will collect data on mobility and balance that will help in gait assessments, which are put into context through a questionnaire sent to the patient. The data is then collectively analyzed through a pipeline of algorithms and AI to determine the next course of action. Depending on the values of the data and answers from the questionnaire, the AI will respond accordingly. In the future, we hope to continue the development of the mobile app as well as seamlessly integrate the aforementioned algorithms and AI to dramatically improve remote health monitoring and collaboration between people living with Multiple Sclerosis and their clinicians.

Project Supervisor: Graham Dove (TMI, CUSP)

Research Area: *Health*



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NYU TANDON SCHOOL OF ENGINEERING

Digital Healthcare Applications for Multiple Sclerosis Rehabilitation

Daniel Wu, Bree Choi, Graham Dove
NYU Tandon School of Engineering

Abstract

There is a desire to use wearable sensors and AI to create a more personalized and targeted treatment plan for patients of Multiple Sclerosis (MS). In addition, these digital technologies will aid in early detection and intervention of the disease. This research explores the importance and impact of digital technologies in the self-management of MS through the design and evaluation of an intuitive mobile app combined with a wearable sensor for remote patient monitoring.

Background

Multiple Sclerosis (MS) is a chronic, autoimmune, and inflammatory disease of the Central Nervous System. It is widely prevalent, affecting 2.8 million people worldwide and more than 900,000 in the US alone. Walking impairment is the disease's most frequent and debilitating symptom, so monitoring symptoms and being physically active are significant in MS self-management.

Methods

The Metawear sensor (see Figure 2) is worn by the patient (see Figure 1) and collects data on mobility and balance that aids in gait assessments. Through the help of AI , the data is understood through a questionnaire sent by the mobile app, and a course of action is chosen accordingly. For example, the patient may respond negatively in the questionnaire, prompting the mobile app to open up a chat room with their clinician, which prevents the need to commute to the clinician's office. The AI's assessment of the data as well as any additional information the patient provides will facilitate an informed conversation between the patient and clinician.

Future Work

We hope to continue the development of the mobile app as well as seamlessly integrate the aforementioned AI to dramatically improve remote health monitoring and collaboration between people living with Multiple Sclerosis and their clinicians.

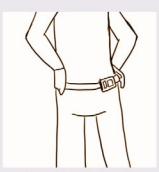


Figure 1: Patient Wearing Sensor



Figure 2: Metawear Sensor

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[2] National Science Foundation (Awards 2129076; 1928614).

Acknowledgement

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DIY ASSISTIVE TECHNOLOGY

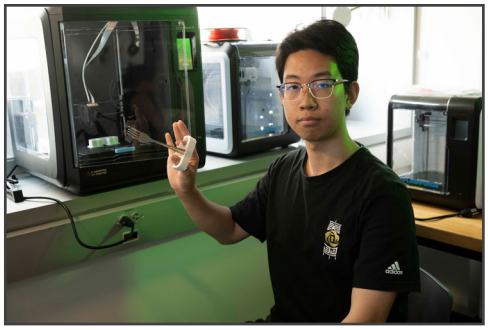
NYU Ability Project is an interdisciplinary research space dedicated to the intersection between disability and technology. Projects are looking to create inclusive systems, design human-centered projects, and further understanding and research in the area of ability. Our projects are intended to be ongoing, multidisciplinary, and client-facing, with a strong emphasis on open-source practices. The process involves developing and applying skills in software, hardware, communication, and/or digital fabrication, including OpenScad, CircuitPython, 3D Printing, etc; identifying solutions to hindrances in accessibility, usability, and durability; as well as iteratively improving existing solutions. Projects also included work with Level The Curve, a company that aims to make everyday life easier for people by creating products that adapt to the customers' needs and wants, to build assistant tools for persons with hand disability. With Gaurav Seth, we model the roundabout and print them with the 3D printer, which proposes the development and integration of 3D-printed tactile maps into roundabout navigation training tools to address these challenges and provide tactile educational materials that are portable, durable, lightweight, and informative.

Project Supervisor: Amy Hurst (TCS); **Ph.D. Student:** Gaurav Seth

Research Area: *Health*

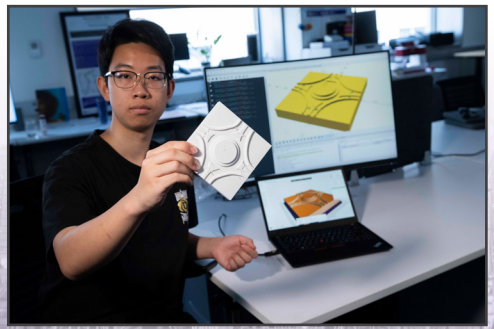


Yiqiao Zhou
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Above: Yiqiao Zhou holding a 3D printed adapted fork holder in the Ability Project. This was designed in collaboration with Level The Curve for individuals with limited finger dexterity to easily hold utensils.

Below: Yiqiao Zhou holding a 3D printed model of a roundabout intersection that he designed. This model was built in collaboration with the Seeing Eye to be used as a training tool for Blind and Low Vision Guide Dog users to learn traffic patterns.





EXOSOMES

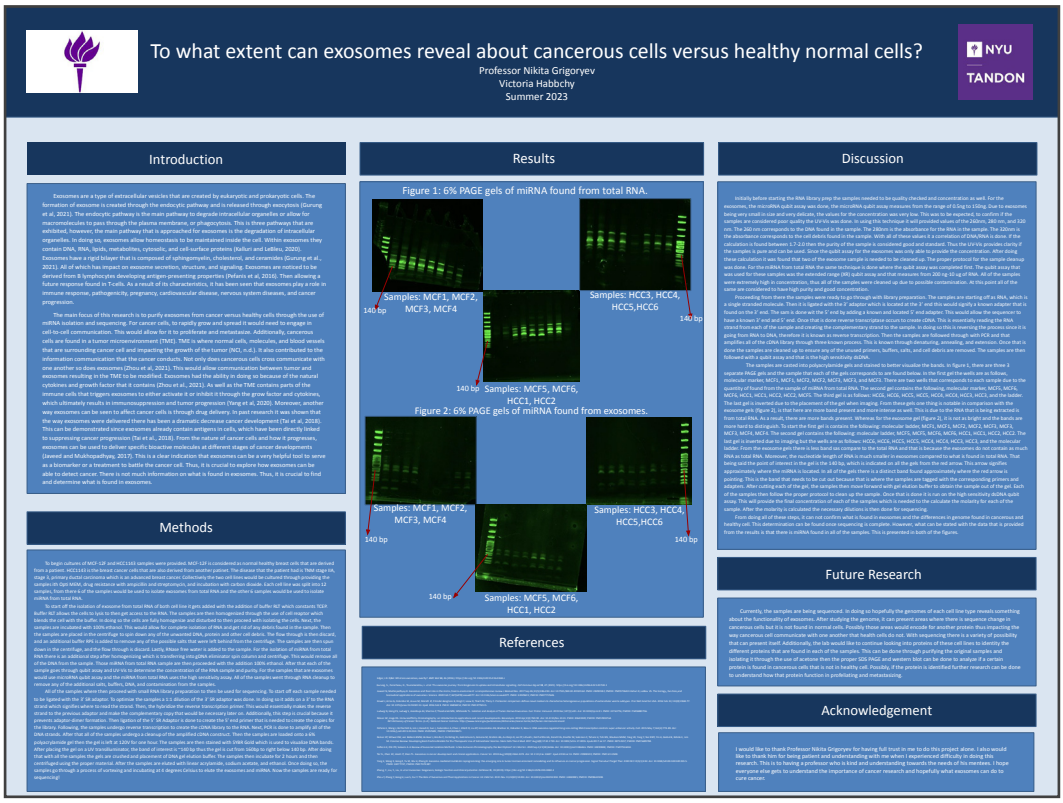
Exosomes are a type of extracellular vesicles that are created by eukaryotic and prokaryotic cells. The formation of an exosome is created through the endocytic pathway and is released through exocytosis. The endocytic pathway is the main pathway to degrade intracellular organelles or allows for macromolecules to pass through the plasma membrane or phagocytosis. These are three pathways that are exhibited, however, the main pathway that is approached for exosomes is the degradation of intracellular organelles. In doing so, exosomes allow homeostasis to be maintained inside the cell. Within exosomes, they contain DNA, RNA, lipids, metabolites, cytosolic, and cell-surface proteins. Exosomes have a rigid bilayer that is composed of sphingomyelin, cholesterol, and ceramides. All of which have an impact on exosome secretion, structure, and signaling. The main focus of this research is to purify exosomes from cancer versus healthy cells through the use of miRNA isolation and sequencing. For cancer cells, to rapidly grow and spread they would need to engage in cell-to-cell communication. This would allow for it to proliferate and metastasize. Additionally, cancerous cells are found in a tumor microenvironment. TME is where normal cells, molecules, and blood vessels that are surrounding cancer cells and impact the growth of the tumor. It also contributed to the information communication that the cancer conducts. Not only do cancerous cells cross-communicate with one another so do exosomes. This is a clear indication that exosomes can be a very helpful tool to serve as a biomarker or a treatment to battle the cancer cell. Thus, it is crucial to explore how exosomes can be able to detect cancer. This can be done through the use of sequencing which is what the lab is currently working on.

Project Supervisor: Nikita Grigoryev (CBE)

Research Area: *Health*



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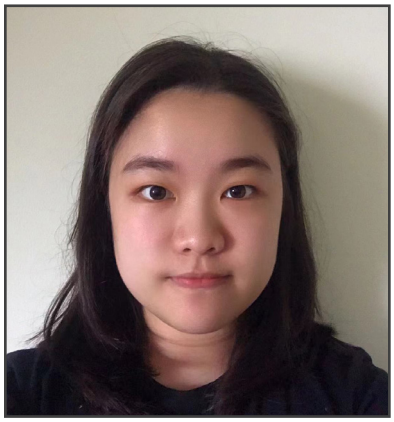


EXPLORING MECHANOTRANSDUCTION IN CAR-T CELL ACTIVATION AND CYTOTOXICITY

(CAR)-T cells are genetically engineered T cells with enhanced antigen-binding and cytotoxic functions and thus defeat cancer cells more effectively than regular T cells. Upon binding with specific antigens (e.g., CD19), CAR-T cells form immunological synapses (IS) with the target cancer cells and initiate their cytotoxic functions. Such a process is highly mechanosensitive due to the mechanical forces exerted by the CAR-T cells onto the cancer cells through the IS. CAR-T cell therapy has shown considerable success in treating hematological malignancies like leukemia. Expanding the application of this therapy to other types of cancers requires a deeper understanding of the role of mechanical forces in activating CAR-T cells and facilitating their cytotoxic function. This research delves into investigating the biophysical mechanism underlying the mechanotransductive pathways of CAR-T cells by employing force-sensing micropillar arrays and immunofluorescent imaging. We specifically focus on the mechanosensitive ion channel protein Piezo-1 as the potential regulator of the mechanotransduction signaling upon CAR-CD19 interaction. Immunostaining techniques are utilized to visualize the proteins of interest in both cancerous and CAR-T cells. Comprehending the mechanisms underlying CAR-T cell activation and cytotoxic functions represents a significant advancement in immunotherapy and holds great potential for discovering effective treatments for a broader range of malignancies.

Project Supervisor: Weiqiang Chen (BME, MAE); **Research Staff:** Kate Luu

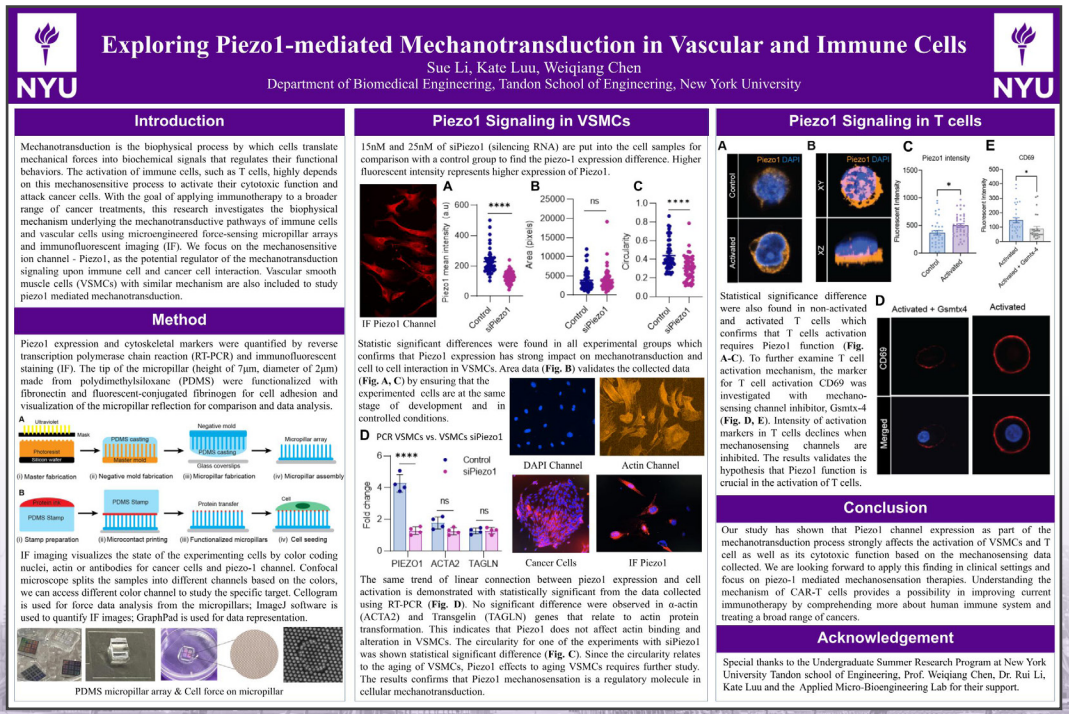
Research Area: *Health*



Sue Li
Chemical and Biomolecular Engineering, B.S., 2025
NYU Tandon School of Engineering



Sue Li uses the microscope to check fabricated micropillars



FOLIC ACID AND FOLATE: SO SIMILAR YET SO DIFFERENT

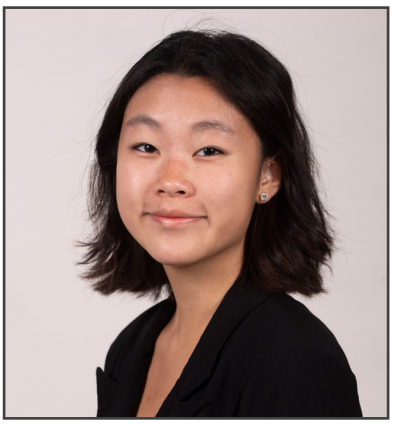
In the 1960s, scientists noticed a connection between gestational deficiency in folate, the natural form of vitamin B9, and neural tube defects (NTDs) in the offspring. This link was later confirmed by additional studies and led to efforts to initiate periconceptional supplementation with folic acid, a synthetic form of folate, drastically reducing the incidence of these malformations. Starting in 1998, several countries have implemented mandatory folic acid food fortification programs. However, although folic acid and folate have very similar chemical structures, they have several differences, making them simultaneously very similar yet very different. In this context, the possibility that these differences could modulate distinct groups of genes emerges as an important question with medical and public health relevance. Using SuperPred, a machine-based prediction tool of genes modulated by small molecules, we comparatively interrogated the gene targets of folate and folic acid, as well as folinic acid, and identified several genes that are modulated by folic acid but not by folate. Additional challenges in folic acid supplementation involve gaps in understanding its benefits and adverse effects among individuals harboring variants in genes involved in folate metabolism, as well as supplementation with folic acid late during pregnancy, which is incompletely studied but from several research efforts appear to increase the risk of certain medical conditions in the developing fetus. Our work aims to promote an up-to-date understanding of the folic acid supplementation discourse, highlighting major gaps in knowledge and empowering individuals to make informed healthcare decisions.

Project Supervisor: Richard A. Stein (CBE)

Research Area: *Health*



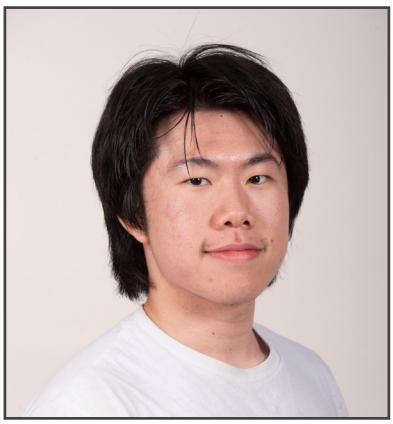
Amisha K. Gopee
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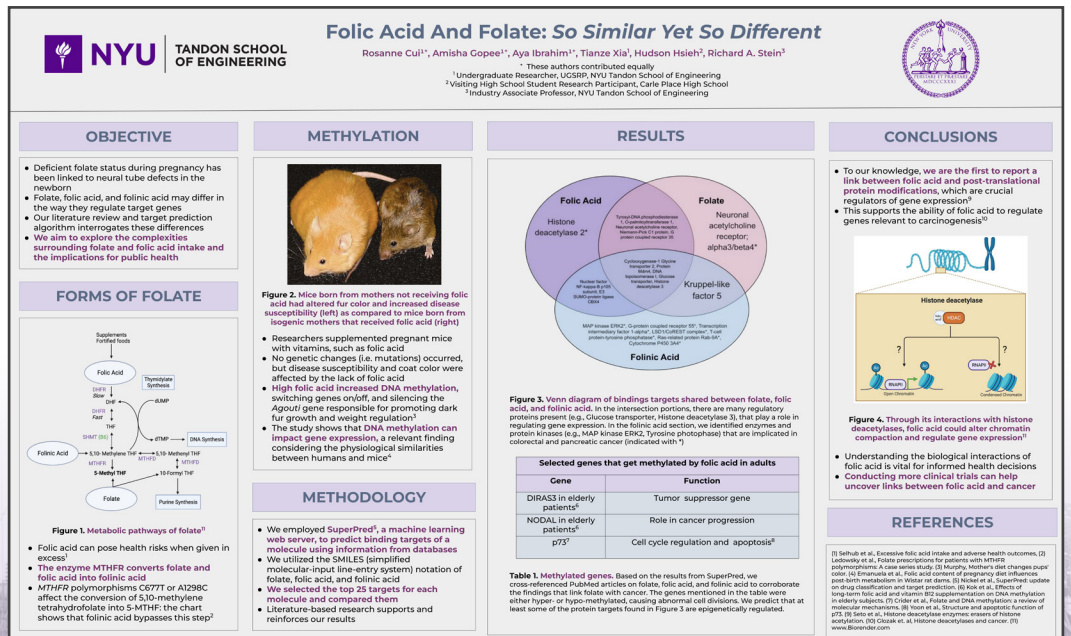
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IDENTIFICATION AND QUANTIFICATION OF ENTEROCOCCUS SPP. SPECIES IN A WASTEWATER TREATMENT PLANT

It was previously observed that wastewater bacteria and laboratory cultured bacteria exhibited different disinfection kinetics. Laboratory cultured Enterococcus spp. had a faster decay rate when exposed to chlorine and monochloramine as compared to wastewater sourced Enterococcus spp., but this differed during sunlight disinfection. Considering that wastewater sourced Enterococcus spp. comprises of over 49 species (Facklam, Carvalho, and Teixeira 2002; Teixeira et al. 2015) whereas the laboratory cultures are typically made up of a single species, this raises the question of whether the genetic variations of species contributed to the disinfection resistance observed in wastewater bacteria. We hypothesize that if the most abundant specie found in wastewater is more resistant to disinfection, then the observed decay rate (k) would be relatively low, however, if the least resistant specie is more prevalent, the observed decay rate would be relatively high. To investigate this, we want to identify and quantify the different enterococci species in wastewater using quantitative polymerase chain reaction (qPCR). This will be conducted quarterly to determine how the seasonal effects influence the bacteria concentration. The significance of this research is that it will provide better insight on how contribution of genetic species' differences to enhanced disinfectant resistance.

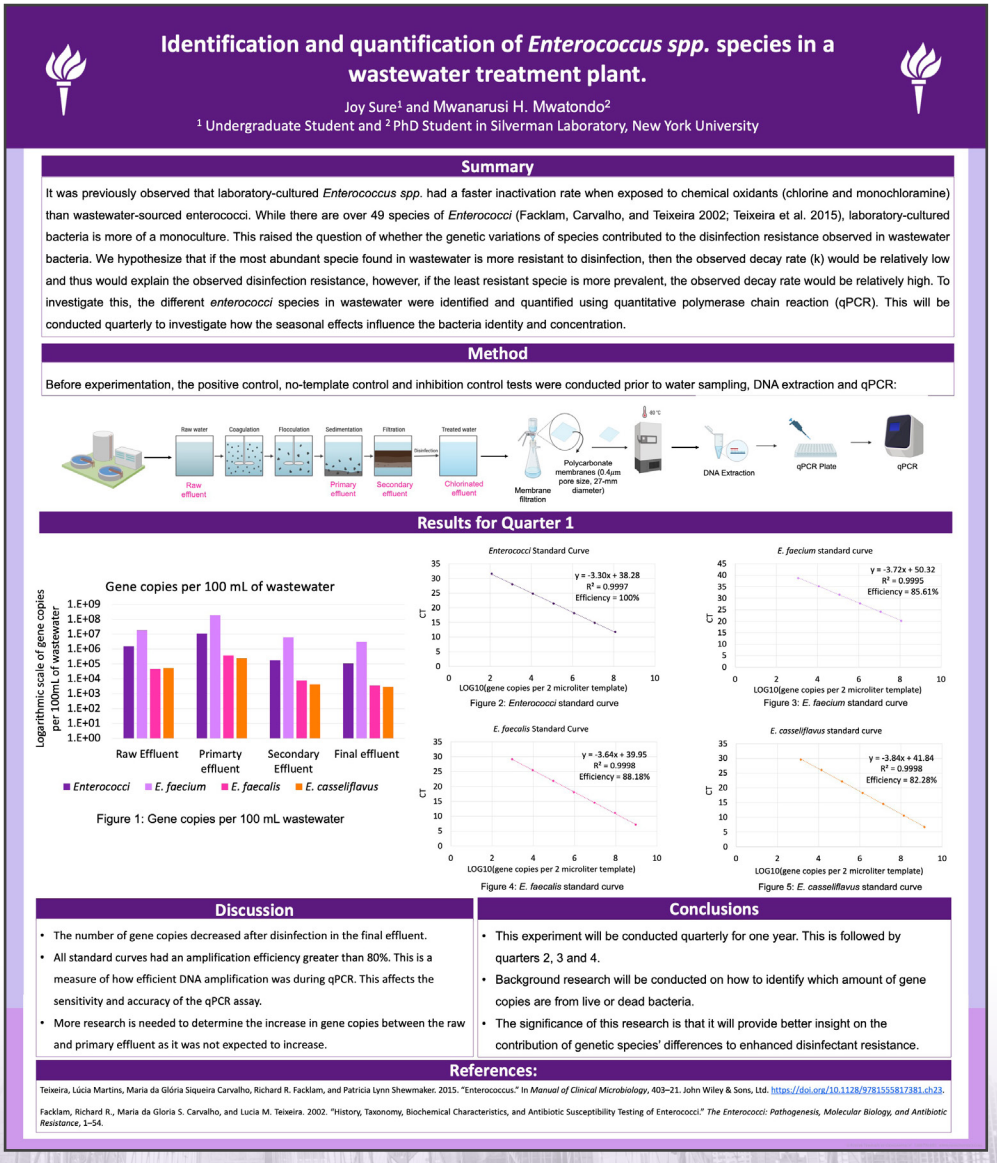
Project Supervisor: Andrea Silverman (CUE); **Research Staff:** Mwanarusi Mwatondo

Research Areas: *Health, Sustainability*



Joy Sure
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GLASS Fellow



Identification and quantification of *Enterococcus spp.* species in a wastewater treatment plant.

Joy Sure[1] and Mwanarusi H. Mwatondo[2]
[1] Undergraduate Student and [2] PhD Student in Silverman Laboratory, New York University

Summary

It was previously observed that laboratory-cultured *Enterococcus spp.* had a faster inactivation rate when exposed to chemical oxidants (chlorine and monochloramine) than wastewater-sourced enterococci. While there are over 49 species of *Enterococci* (Facklam, Carvalho, and Teixeira 2002; Teixeira et al. 2015), laboratory-cultured bacteria is more of a monoculture. This raised the question of whether the genetic variations of species contributed to the disinfection resistance observed in wastewater bacteria. We hypothesize that if the most abundant specie found in wastewater is more resistant to disinfection, then the observed decay rate (k) would be relatively low and thus would explain the observed disinfection resistance, however, if the least resistant specie is more prevalent, the observed decay rate would be relatively high. To investigate this, the different *enterococci* species in wastewater were identified and quantified using quantitative polymerase chain reaction (qPCR). This will be conducted quarterly to investigate how the seasonal effects influence the bacteria identity and concentration.

Method

Before experimentation, the positive control, no-template control and inhibition control tests were conducted prior to water sampling, DNA extraction and qPCR:

Results for Quarter 1

Figure 1: Gene copies per 100 mL wastewater

Figure 2: *Enterococci* standard curve

Figure 3: *E. faecium* standard curve

Figure 4: *E. faecalis* standard curve

Figure 5: *E. casseliflavus* standard curve

Discussion

- The number of gene copies decreased after disinfection in the final effluent.
- All standard curves had an amplification efficiency greater than 80%. This is a measure of how efficient DNA amplification was during qPCR. This affects the sensitivity and accuracy of the qPCR assay.
- More research is needed to determine the increase in gene copies between the raw and primary effluent as it was not expected to increase.

Conclusions

- This experiment will be conducted quarterly for one year. This is followed by quarters 2, 3 and 4.
- Background research will be conducted on how to identify which amount of gene copies are from live or dead bacteria.
- The significance of this research is that it will provide better insight on the contribution of genetic species' differences to enhanced disinfectant resistance.

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IDENTIFICATION OF UNIVERSAL PRIMERS FOR V4 REGION USING 16S METAGENOMIC SEQUENCING

The highly-conserved 16s rRNA gene codes for the ribosome and contains nine variable regions (V1-V9). The variable regions have sequences that are particular to the type of the organism present and are thus often used to distinguish between closely related species using Metagenomic sequencing. Although the full V1–V9 region consistently produced the best results, the V3–V5 region produced good results for Klebsiella, and the V1–V3 region produced good results for Escherichia/Shigella (Johnson et al. 2019). The Earth Microbiome Project, which aims to characterize and interpret the microbial diversity and functional potential of thousands of environmental samples, uses primers that target the V4 hypervariable region (Thompson et al. 2017). The Earth Microbiome region found that the V4 region was able to extract most bacterial and archaic sequences except for recently discovered organisms (Thompson et al. 2017). In 16S rRNA gene sequencing, certain bacterial genera were found to be underrepresented or even missing in taxonomic profiles when using unsuitable primer combinations, outdated reference databases, or inadequate pipeline settings (Schneyder et al. 2021). The purpose of this study is to determine if there is a universal primer for the V4 region that can provide accurate sequencing results and identify a wide range of bacteria.

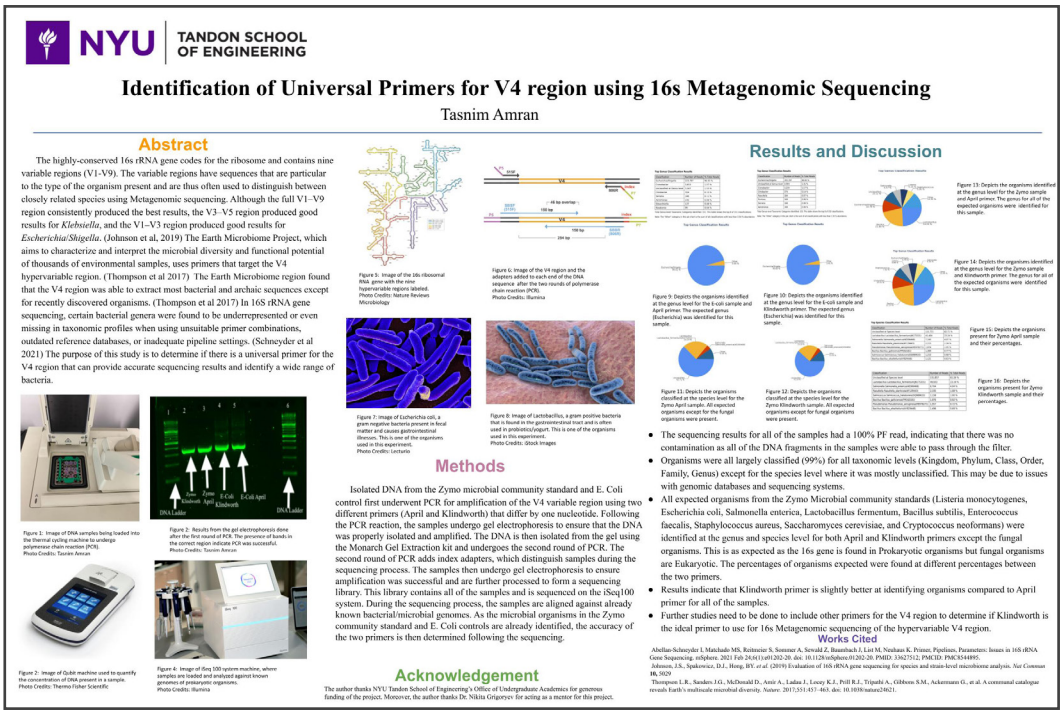
Isolated DNA from the Zymo microbial community standard and E. Coli control first underwent PCR for amplification of the V4 variable region using two different primers (April and Klindworth) that differ by one nucleotide. Following the PCR reaction, the samples undergo gel electrophoresis to ensure that the DNA was properly isolated and amplified. The DNA is then isolated from the gel using the Monarch Gel Extraction kit and undergoes the second round of PCR. The second round of PCR adds index adapters, which distinguish samples during the sequencing process. The samples then undergo gel electrophoresis to ensure amplification was successful and are further processed to form a sequencing library. This library contains all of the samples and is sequenced on the iSeq100 system. During the sequencing process, the samples are aligned against already known bacterial/microbial genomes. As the microbial organisms in the Zymo community standard and E. Coli controls are already identified, the accuracy of the two primers is then determined following the sequencing.

Project Supervisor: Nikita Grigoryev (CBE)

Research Area: *Health*



Tasnim Amran
Biomolecular Science, B.S., 2024
NYU Tandon School of Engineering



NYU TANDON SCHOOL OF ENGINEERING

Identification of Universal Primers for V4 region using 16s Metagenomic Sequencing

Tasnim Amran

Abstract

The highly-conserved 16s rRNA gene codes for the ribosome and contains nine variable regions (V1-V9). The variable regions have sequences that are particular to the type of the organism present and are thus often used to distinguish between closely related species using Metagenomic sequencing. Although the full V1–V9 region consistently produced the best results, the V3–V5 region produced good results for *Klebsiella*, and the V1–V3 region produced good results for *Escherichia/Shigella*. (Johnson et al, 2019) The Earth Microbiome Project, which aims to characterize and interpret the microbial diversity and functional potential of thousands of environmental samples, uses primers that target the V4 hypervariable region. (Thompson et al 2017) The Earth Microbiome region found that the V4 region was able to extract most bacterial and archaic sequences except for recently discovered organisms. (Thompson et al 2017) In 16S rRNA gene sequencing, certain bacterial genera were found to be underrepresented or even missing in taxonomic profiles when using unsuitable primer combinations, outdated reference databases, or inadequate pipeline settings. (Schneyder et al 2021) The purpose of this study is to determine if there is a universal primer for the V4 region that can provide accurate sequencing results and identify a wide range of bacteria.

Figure 1: Image of DNA samples being loaded into the thermal cycling machine to undergo polymerase chain reaction (PCR).
Photo Credits: Tasnim Amran

Figure 2: Results from the gel electrophoresis done after the first round of PCR. The presence of bands in the correct region indicate PCR was successful.
Photo Credits: Tasnim Amran

Figure 4: Image of iSeq 100 system machine, where samples are loaded and analyzed against known genomes of prokaryotic organisms.
Photo Credits: Illumina

Figure 5: Image of the 16s ribosomal RNA gene with the nine hypervariable regions labeled.
Photo Credits: Nature Reviews Microbiology

Figure 6: Image of the V4 region and the adapters added to each end of the DNA sequence after the two rounds of polymerase chain reaction (PCR).
Photo Credits: Illumina

Figure 7: Image of Escherichia coli, a gram negative bacteria present in fecal matter and causes gastrointestinal illnesses. This is one of the organisms used in this experiment.
Photo Credits: Lecturio

Figure 8: Image of Lactobacillus, a gram positive bacteria that is found in the gastrointestinal tract and is often used in probiotics/yogurt. This is one of the organisms used in this experiment.
Photo Credits: Glock Images

Methods

Isolated DNA from the Zymo microbial community standard and E. Coli control first underwent PCR for amplification of the V4 variable region using two different primers (April and Klindworth) that differ by one nucleotide. Following the PCR reaction, the samples undergo gel electrophoresis to ensure that the DNA was properly isolated and amplified. The DNA is then isolated from the gel using the Monarch Gel Extraction kit and undergoes the second round of PCR. The second round of PCR adds index adapters, which distinguish samples during the sequencing process. The samples then undergo gel electrophoresis to ensure amplification was successful and are further processed to form a sequencing library. This library contains all of the samples and is sequenced on the iSeq100 system. During the sequencing process, the samples are aligned against already known bacterial/microbial genomes. As the microbial organisms in the Zymo community standard and E. Coli controls are already identified, the accuracy of the two primers is then determined following the sequencing.

Acknowledgement

The author thanks NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Moreover, the author thanks Dr. Nikita Grigoryev for acting as a mentor for this project.

Results and Discussion

Figure 13: Depicts the organisms identified at the genus level for the Zymo sample and April primer. The genus for all of the expected organisms were identified for this sample.

Figure 9: Depicts the organisms identified at the genus level for the E-coli sample and April primer. The expected genus (Escherichia) was identified for this sample.

Figure 10: Depicts the organisms identified at the genus level for the E-coli sample and Klindworth primer. The expected genus (Escherichia) was identified for this sample.

Figure 14: Depicts the organisms identified at the genus level for the Zymo sample and Klindworth primer. The genus for all of the expected organisms were identified for this sample.

Figure 11: Depicts the organisms classified at the species level for the Zymo April sample. All expected organisms except for the fungal organisms were present.

Figure 12: Depicts the organisms classified at the species level for the Zymo Klindworth sample. All expected organisms except for fungal organisms were present.

Figure 15: Depicts the organisms present for Zymo April sample and their percentages.

Figure 16: Depicts the organisms present for Zymo Klindworth sample and their percentages.

- The sequencing results for all of the samples had a 100% PF read, indicating that there was no contamination as all of the DNA fragments in the samples were able to pass through the filter.
- Organisms were all largely classified (99%) for all taxonomic levels (Kingdom, Phylum, Class, Order, Family, Genus) except for the species level where it was mostly unclassified. This may be due to issues with genomic databases and sequencing systems.
- All expected organisms from the Zymo Microbial community standards (Listeria monocytogenes, Escherichia coli, Salmonella enterica, Lactobacillus fermentum, Bacillus subtilis, Enterococcus faecalis, Staphylococcus aureus, Saccharomyces cerevisiae, and Cryptococcus neoformans) were identified at the genus and species level for both April and Klindworth primers except the fungal organisms. This is as expected as the 16s gene is found in Prokaryotic organisms but fungal organisms are Eukaryotic. The percentages of organisms expected were found at different percentages between the two primers.
- Results indicate that Klindworth primer is slightly better at identifying organisms compared to April primer for all of the samples.
- Further studies need to be done to include other primers for the V4 region to determine if Klindworth is the ideal primer to use for 16s Metagenomic sequencing of the hypervariable V4 region.

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LIGHT-RESPONSIVE MODEL PRODRUG UNCAGING IN RESPONSE TO ENVIRONMENTAL STIMULI

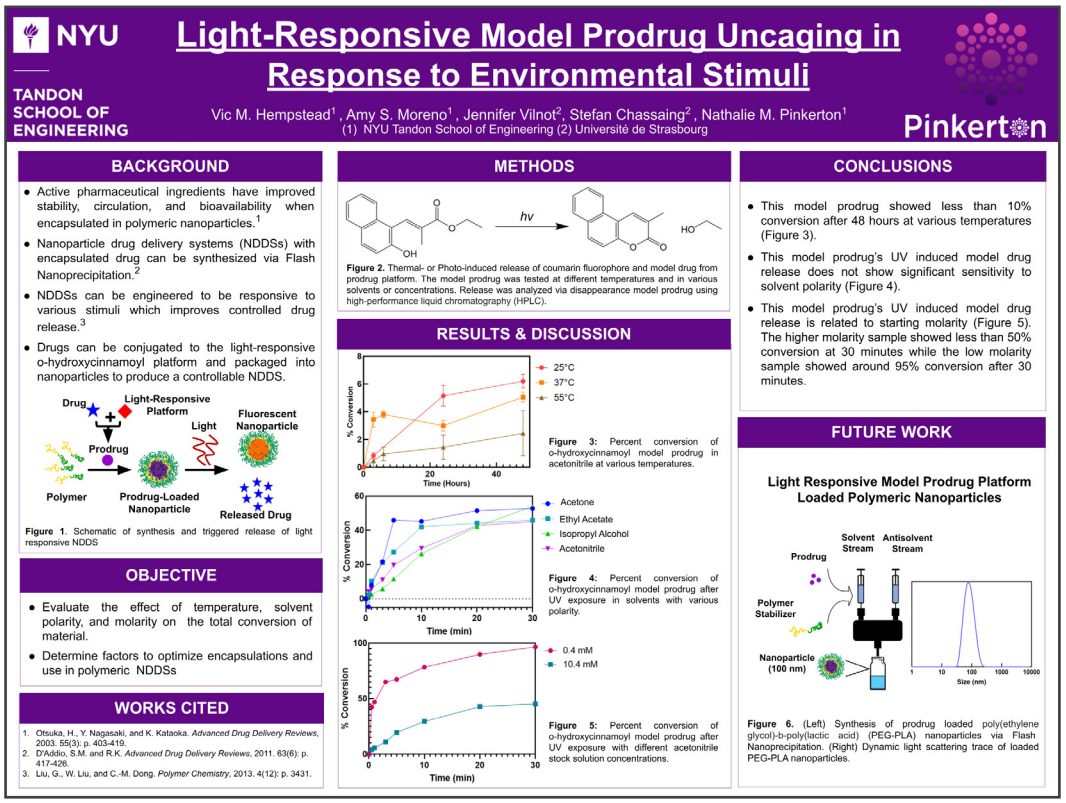
Encapsulation of therapeutic agents in nanocarriers has the potential to improve control over localized drug delivery. Nanocarriers can be designed to release encapsulated molecules in response to various stimuli, such as temperature, pH, or light. The use of light in medicine is particularly useful since the method can be remote, minimally invasive, and easy to manipulate through wavelength, intensity, and duration. Light-responsive platforms release therapeutic agents through photochemical processes, known as light responsive uncaging. O-hydroxycinnamoyl-based molecules/structures (o-HA) is one such platform which can uncage, or release, a conjugated small molecule with UV exposure. The o-HA used in this study releases an ethanol molecule from the larger platform as a result of a trans- to cis-isomerization and cyclization. Through this isomerization and uncaging, the prodrug platform transforms into a coumarin-based dye which can be easily quantified and tracked to monitor model-drug release. However, in addition to UV exposure, uncaging and rate of model drug release can be influenced by other factors in the surrounding environment. Factors such as temperature, polarity, and concentration have the potential to trigger, delay, or accelerate uncaging and model drug release. To properly understand this mechanism and potential applications of this platform, O-hydroxycinnamic acid's total amount of release needs to be quantified in a variety of stimuli. This project seeks to quantify the effect of temperature, solvent type, and concentration on the rate of uncaging from the O-hydroxycinnamic acid platform, and identify the most influential parameter to maximize uncaging.

Project Supervisor: Nathalie Pinkerton (CBE); **Research Staff:** Amy Moreno

Research Area: *Health*



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NYU Tandon School of Engineering



LN-ON-A-CHIP TO MODEL HUMAN ADAPTIVE IMMUNE RESPONSE AND ASSESS VACCINE EFFICACY IN DIFFERENT POPULATIONS

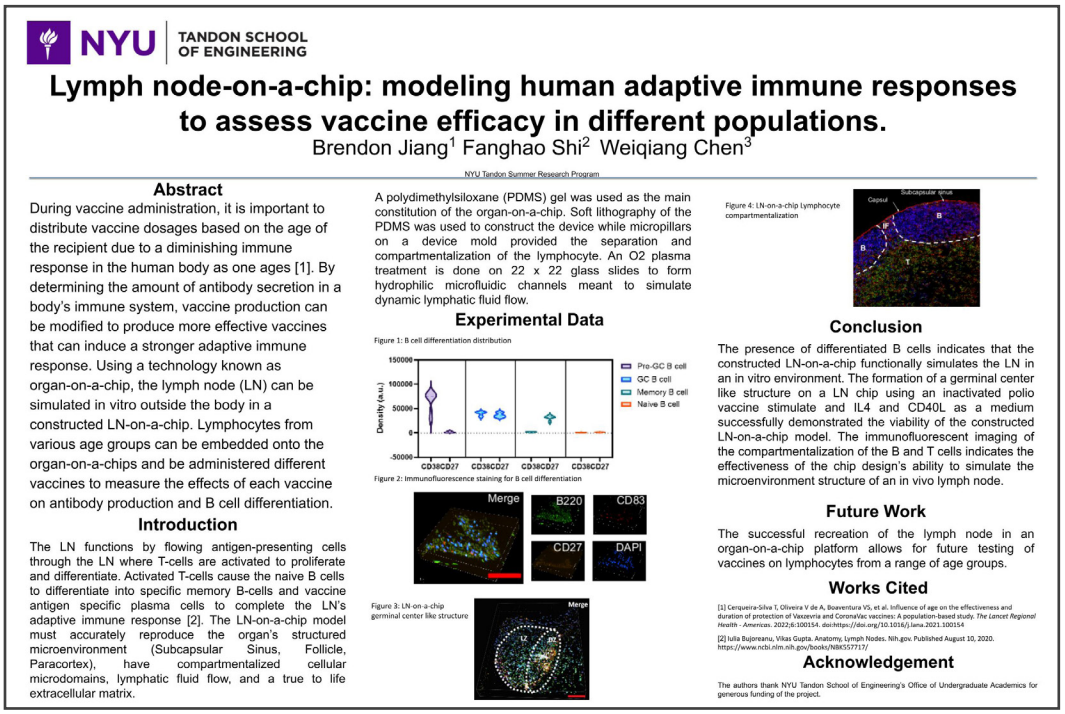
Pharmaceutical drug development faces over a 96% failure rate during the developmental stage mostly due to the lack of a cheap and easily accessible platform for immunotoxicity testing. The organ-on-a-chip technology provides a powerful yet cheap platform for drug immunotoxicity testing which can ultimately reduce developmental costs and improve FDA approval rates. By simulating an in vivo-like microenvironment with microstructures, cells can be grown to simulate the functional unit of an organ in vitro without the complexity and variability of an in vivo model. The human lymph node (LN) is responsible for adaptive immune responses to drugs entering the body. A LN-on-a-chip model can be used to evaluate the cellular response to experimental drugs but a viable model has not been properly developed for use in research settings. The LN functions by flowing antigen-presenting cells through the LN where T-cells are activated to proliferate and differentiate. Activated T-cells cause the naive B cells to differentiate into specific memory B-cells and vaccine antigen specific plasma cells to complete the LN's adaptive immune response. The LN-on-a-chip model must accurately reproduce the organ's structured microenvironment (Subcapsular Sinus, Follicle, Paracortex), have compartmentalized cellular microdomains, lymphatic fluid flow, and a true to life extracellular matrix. Soft lithography of polydimethylsiloxane (PDMS) is used to construct the device while micropillars on a device mold provide separation and compartmentalization of the lymphocyte. An O2 plasma treatment is done on 22 x 22 glass slides to form hydrophilic microfluidic channels meant to simulate dynamic lymphatic fluid flow. Immunofluorescent techniques will be used to evaluate the movement of T cells and dendritic cells, proliferation and differentiation of T cells, as well as the formation of germinal centers. ELISA will be performed to observe changes in the cytokine associated with T cell proliferation as well as the concentration of antibody secretion to evaluate the effects of vaccines on differing populations.

Project Supervisor: Weiqiang Chen (BME, MAE); **Research Staff:** Lunan Liu, Huishu Wang; **Other Collaborators:** Neil Thomas

Research Area: *Health*



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Biomolecular Science, B.S., 2025
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NYU TANDON SCHOOL OF ENGINEERING

Lymph node-on-a-chip: modeling human adaptive immune responses to assess vaccine efficacy in different populations.

Brendon Jiang[1] Fanghao Shi[2] Weiqiang Chen[3]

NYU Tandon Summer Research Program

Abstract

During vaccine administration, it is important to distribute vaccine dosages based on the age of the recipient due to a diminishing immune response in the human body as one ages [1]. By determining the amount of antibody secretion in a body's immune system, vaccine production can be modified to produce more effective vaccines that can induce a stronger adaptive immune response. Using a technology known as organ-on-a-chip, the lymph node (LN) can be simulated in vitro outside the body in a constructed LN-on-a-chip. Lymphocytes from various age groups can be embedded onto the organ-on-a-chips and be administered different vaccines to measure the effects of each vaccine on antibody production and B cell differentiation.

Introduction

The LN functions by flowing antigen-presenting cells through the LN where T-cells are activated to proliferate and differentiate. Activated T-cells cause the naive B cells to differentiate into specific memory B-cells and vaccine antigen specific plasma cells to complete the LN's adaptive immune response [2]. The LN-on-a-chip model must accurately reproduce the organ's structured microenvironment (Subcapsular Sinus, Follicle, Paracortex), have compartmentalized cellular microdomains, lymphatic fluid flow, and a true to life extracellular matrix.

A polydimethylsiloxane (PDMS) gel was used as the main constitution of the organ-on-a-chip. Soft lithography of the PDMS was used to construct the device while micropillars on a device mold provided the separation and compartmentalization of the lymphocyte. An O2 plasma treatment is done on 22 x 22 glass slides to form hydrophilic microfluidic channels meant to simulate dynamic lymphatic fluid flow.

Experimental Data

Figure 1: B cell differentiation distribution

Figure 2: Immunofluorescence staining for B cell differentiation

Figure 3: LN-on-a-chip germinal center like structure

Figure 4: LN-on-a-chip Lymphocyte compartmentalization

Conclusion

The presence of differentiated B cells indicates that the constructed LN-on-a-chip functionally simulates the LN in an in vitro environment. The formation of a germinal center like structure on a LN chip using an inactivated polio vaccine stimulate and IL4 and CD40L as a medium successfully demonstrated the viability of the constructed LN-on-a-chip model. The immunofluorescent imaging of the compartmentalization of the B and T cells indicates the effectiveness of the chip design's ability to simulate the microenvironment structure of an in vivo lymph node.

Future Work

The successful recreation of the lymph node in an organ-on-a-chip platform allows for future testing of vaccines on lymphocytes from a range of age groups.

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Acknowledgement

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

METATRANSCRIPTOMICS

Meta genome wide studies are ubiquitously used to characterize a variety of microbial environments, such as the human gut microbiome, aquatic environments, and terrestrial environments. Metagenomics involves extracting and isolating DNA, performing PCR to amplify a target gene, sequencing the amplified DNA, and analyzing the results in a genome database in order to distinguish the species identity of the sample. Highly conserved genes are typically amplified, such as the 16S rRNA and 23S rRNA genes. These target genes are widely used to identify the species origin of a sample. Metagenomic practices allow researchers to identify and analyze the community composition of an environmental sample. However, there are limitations to the degree of information that metagenomics can provide about a particular environmental sample. Metagenomics does not distinguish between active and inactive members of an environment. The activity of a species in this sense refers to their biological and chemical contribution to the environment. Metatranscriptomics can bypass this limitation by providing information about the transcriptome, which is the portion of DNA that gets actively transcribed during the process of making proteins. In other words, this is the functional part of the genome. Metatranscriptomics involves the isolation and preservation of RNA, which has proven to be much more difficult than its DNA counterpart due to the large range of transcript expression and the instability of RNA. Historically, it has been difficult to always capture the entire metatranscriptome due to these reasons. The goal of this project is to optimize RNA isolation and metatranscriptomic protocols for downstream applications, and eventually apply the findings to environmental samples.

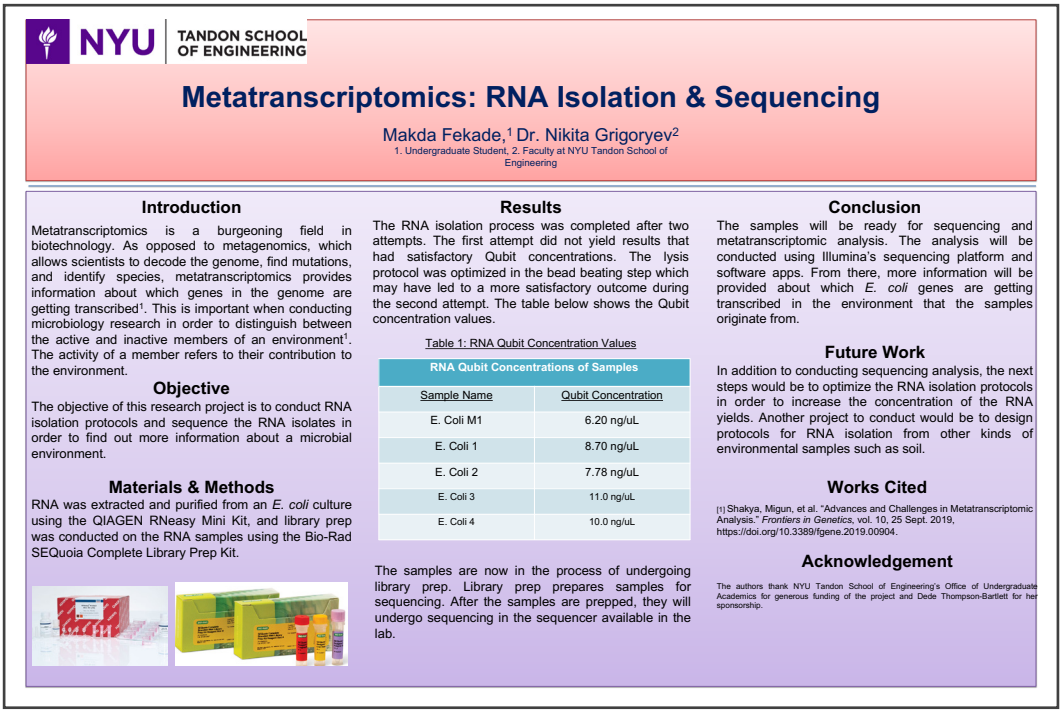
Project Supervisor: Nikita Grigoryev (CBE)

Research Area: *Health*



Makda Fekade
Biomolecular Science, B.S., 2023
NYU Tandon School of Engineering

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NYU TANDON SCHOOL OF ENGINEERING

Metatranscriptomics: RNA Isolation & Sequencing

Makda Fekade,[1] Dr. Nikita Grigoryev[2]
1. Undergraduate Student, 2. Faculty at NYU Tandon School of Engineering

Introduction

Metatranscriptomics is a burgeoning field in biotechnology. As opposed to metagenomics, which allows scientists to decode the genome, find mutations, and identify species, metatranscriptomics provides information about which genes in the genome are getting transcribed[1]. This is important when conducting microbiology research in order to distinguish between the active and inactive members of an environment[1]. The activity of a member refers to their contribution to the environment.

Objective

The objective of this research project is to conduct RNA isolation protocols and sequence the RNA isolates in order to find out more information about a microbial environment.

Materials & Methods

RNA was extracted and purified from an *E. coli* culture using the QIAGEN RNeasy Mini Kit, and library prep was conducted on the RNA samples using the Bio-Rad SEQuoia Complete Library Prep Kit.

Results

The RNA isolation process was completed after two attempts. The first attempt did not yield results that had satisfactory Qubit concentrations. The lysis protocol was optimized in the bead beating step which may have led to a more satisfactory outcome during the second attempt. The table below shows the Qubit concentration values.

Table 1: RNA Qubit Concentration Values

RNA Qubit Concentrations of Samples	
Sample Name	Qubit Concentration
E. Coli M1	6.20 ng/uL
E. Coli 1	8.70 ng/uL
E. Coli 2	7.78 ng/uL
E. Coli 3	11.0 ng/uL
E. Coli 4	10.0 ng/uL

The samples are now in the process of undergoing library prep. Library prep prepares samples for sequencing. After the samples are prepped, they will undergo sequencing in the sequencer available in the lab.

Conclusion

The samples will be ready for sequencing and metatranscriptomic analysis. The analysis will be conducted using Illumina's sequencing platform and software apps. From there, more information will be provided about which *E. coli* genes are getting transcribed in the environment that the samples originate from.

Future Work

In addition to conducting sequencing analysis, the next steps would be to optimize the RNA isolation protocols in order to increase the concentration of the RNA yields. Another project to conduct would be to design protocols for RNA isolation from other kinds of environmental samples such as soil.

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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 Dede Thompson-Bartlett for her sponsorship.

MODULAR 3D-PRINTED APPROACH FOR THE SYNTHESIS OF MICRO & NANOPARTICLES THROUGH SEQUENTIAL NANOPRECIPITATION

Sequential nanoprecipitation (SNaP) is an emerging synthesis process for the formation of nanoparticles for drug delivery. This process relies on the same principle as traditional flash nanoprecipitation, however, it consists of decoupling the core formation step from the stabilization. The current methods for achieving sequential nanoprecipitation rely on the use of commercially available mixers connected in a series arrangement. Although, their use presented efficient control over the synthesis parameters, these mixers are usually expensive, and their use is limited to the models, materials, and dimensions commercially available. In this work, we present a 3D-printed, modular approach to rapidly prototype millifluidic mixers for Sequential Nanoprecipitation. This presented a reproducible, scalable approach for the formation of tunable polymeric nano and microparticles ranging from 200 nm up to 3 μm in diameter. These particles can be used for both drug delivery and imaging depending on the core composition. We also presented a simple method for varying the delay time which we also evidenced its importance for the control of the synthesis outcome. This approach presents a rapid, low-cost, and flexible method for designing and prototyping mixers for sequential nanoprecipitation.

Project Supervisor: Nathalie Pinkerton (CBE); **Research Staff:** Erica Burnham

Research Area: *Health*



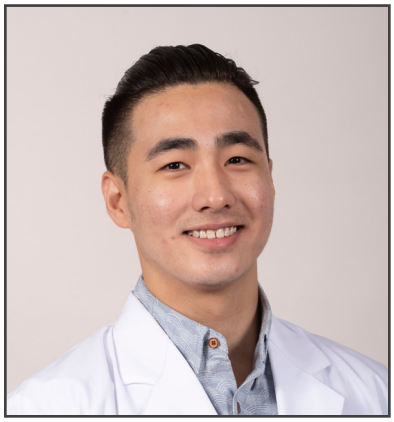
Thomas Belinky
Mechanical Engineering, B.S., 2024
NYU Tandon School of Engineering

MONITORING GLIOBLASTOMA PROGRESSION THROUGH CRISPR MEDIATED GFP-TAGGING OF SOX2 GENE

Glioblastoma, the most common and deadly brain cancer in adults, has been closely linked with the elevated expression of the SOX2 gene, underscoring the need to understand its regulation within cancer cells. Using CRISPR/Cas9 genome editing tool, we integrated a green fluorescent protein (GFP) tag to the SOX2 gene within glioblastoma cells, thereby enabling the visualization of SOX2 gene activity. This process involved the design and transfection of three guide RNAs, along with donor DNA and Cas9 nuclease, into glioblastoma cells to induce the gene edit through Homology-Directed Repair (HDR). Our donor DNA was uniquely designed to form a non-fusion between the target gene and tag, using a 2A self-cleaving peptide to minimize the chance of the GFP affecting the natural folding and localization of the SOX2 protein, thus preserving its native function in cells. We confirmed the successful incorporation through fluorescence microscopy and genome sequencing using Illumina iSeq 100 system. This research introduces a novel method for tracking SOX2 gene activity as a potential marker for tumor progression.

Project Supervisor: Nikita Grigoryev (CBE)

Research Area: *Health*



Maksat (Max) Khobdabayev
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NYU TANDON SCHOOL OF ENGINEERING

Monitoring Glioblastoma Progression through CRISPR Mediated GFP-Tagging of SOX2 Gene

Maksat Khobdabayev,[1] Nikita Grigoryev[2]

1. Undergraduate researcher, NYU Abu Dhabi 2. Industry Assistant Professor, NYU Tandon

Abstract

We examined the SOX2 gene, known for high expression in malignancies like glioblastoma and its association with tumor-initiating cells. Using CRISPR/Cas9, we tagged the SOX2 gene in glioblastoma cells with GFP to visualize its activity. This was achieved through transfection with guide RNAs, donor DNA, and Cas9, followed by Homology-Directed Repair (HDR). Successful tag integration was verified with Illumina iSeq 100 sequencing. This study presents a new approach to monitor SOX2 activity, potentially marking tumor progression.

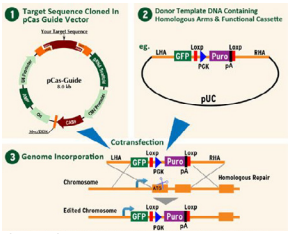
Background on the Project

SOX2 transcription factor maintains embryonic stem cell pluripotency and neural stem cell activity [1]. It is notably elevated in many cancers, including glioblastoma (GBM), the most common and aggressive primary brain tumor in adults [2]. GBMs are particularly resistant to therapy, with average survival around 15 months, characterized by unlimited self-renewal capacity and multilineage differentiation [2].

While SOX2's role as a driver in GBM progression is clear, its transcriptional regulation remains complex [2]. In this study, we GFP-tagged the SOX2 gene in GBM cells using CRISPR/Cas9 technology.

Methodology

We used CRISPR/Cas9 to integrate a GFP tag into the SOX2 gene of GBM cell lines U118 and U87. Three guide RNAs (gRNAs) for SOX2 were designed via the Thermo Fisher tool. Alongside, a GFP donor DNA with relevant homology arms was synthesized. The cells were then co-transfected with the gRNAs, Cas9, and GFP donor, aiming for precise gene editing.



After transfection, we selected cells with antibiotics to ensure only those with proper DNA integration survived. GFP-tagged SOX2 was confirmed by fluorescence microscopy and PCR. Genomic DNA from these cells was PCR-amplified and sequenced using the Illumina iSeq 100 system.

Results

Fluorescence microscopy confirmed distinct GFP expression, indicating successful genomic editing. This finding was further validated by PCR, where sequences from the Illumina iSeq 100 system matched the expected GFP-tagged SOX2 sequences. Phenotypic assays showed consistent growth rates between GFP-tagged and non-tagged cells, and the tagged cells displayed SOX2's characteristic nuclear distribution.

Future Work

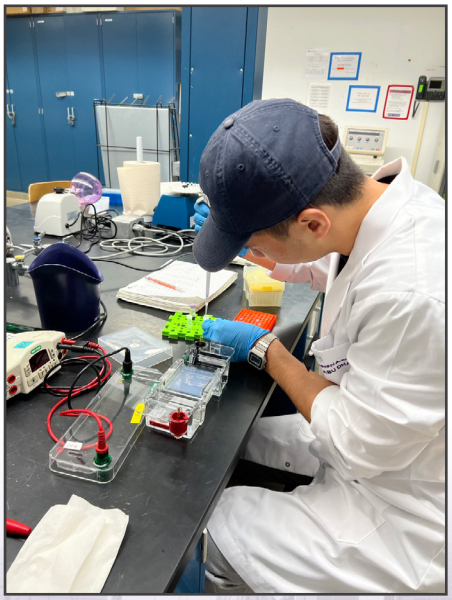
Expanding upon our GFP-tagged SOX2 GBM cells, we aim to determine if the GFP tag influences SOX2's core functions, specifically in stemness maintenance and tumorigenesis. By comparing the tagged cells with their untagged counterparts, we can discern any variations in their proliferative and differentiation potentials. Additionally, these GFP-tagged cells can be used to gauge drug sensitivity against various chemotherapeutic agents, potentially leading to enhanced treatment strategies. Lastly, real-time imaging of the GFP-tagged SOX2 will provide insights into its intracellular dynamics, offering a deeper understanding of its role in GBM.

Works Cited

[1] Sarkar, A., & Hochedlinger, K. (2013). The sox family of transcription factors: versatile regulators of stem and progenitor cell fate. Cell stem cell, 12(1), 15-30.
[2] Garros-Regulez, L., Garcia, I., Carrasco-Garcia, E., Lantero, A., Aldaz, P., Moreno-Cugnon, L., & Matheu, A. (2016). Targeting SOX2 as a therapeutic strategy in glioblastoma. Frontiers in oncology, 6, 222.

Acknowledgement

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







NOVEL PHEMA-YLATED NANOPARTICLES ASSEMBLED BY FLASH NANOPRECIPITATION FOR PAIN DRUG DELIVERY

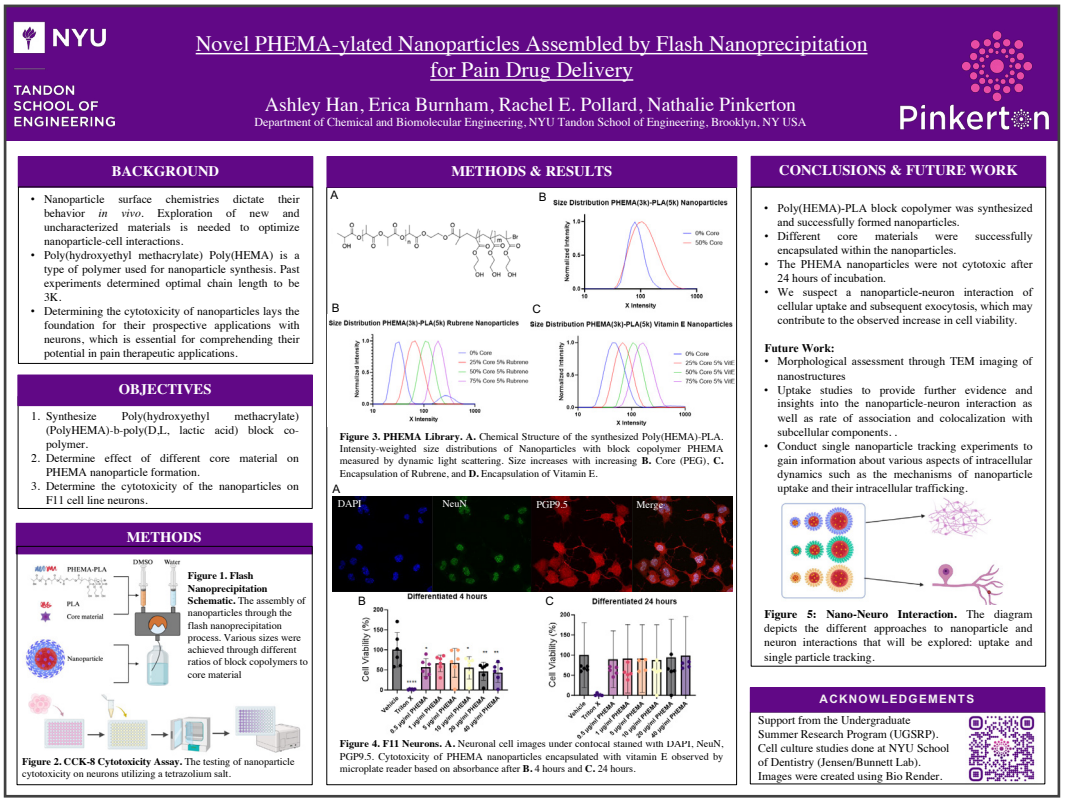
In the rapidly evolving field of nanomedicine and nanodelivery systems, targeted drug delivery to sensory neurons is a complex problem. These systems offer the promise of targeted tissue and cell interactions, extended circulation times, and improved shelf stability. However, issues with conventional block co-polymers as nanoparticle shells, such as accelerated blood clearance, has raised questions about their suitability, leading us to reevaluate our understanding and explore alternative biocompatible polymeric materials. To bridge this knowledge gap and optimize drug delivery to neurons we investigate other potential polymeric materials that can form nanoparticles and interact favorably with neuronal cells. Our approach involves designing a comprehensive library utilizing the flash nanoprecipitation (FNP) assembly process to create nanoparticles made with a synthesized poly(hydroxylethylmethacrylate)-b-PLA (PHEMA-PLA) block co-polymer encapsulating various core materials such as rubrene and vitamin E. Here, we report the first use of PHEMA as a nanoparticle brush surface and investigate its use for neuronal drug delivery. Using cytotoxicity assay to evaluate neurons exposed to nanoparticles offers valuable insights for our library. When assembling nanoparticles with PHEMA-PLA with block chain lengths 3kDa (PHEMA) and 10kDa (PLA), it was seen that a hydrophobic core material was necessary for efficient formation. Then when testing them in using the CCK-8 cytotoxicity assay, they were seen to not be significantly toxic with even an increase in viability after 20 hours of first time point. We suspect that there are other interaction between the neurons and the nanoparticles that contribute to this result and further testing must be done to decisively conclude what is happening. With these new results we are closer to unlocking new possibilities for efficient and targeted drug delivery to neurons, advancing the frontier of therapeutic applications for neurological conditions.

Project Supervisor: Nathalie Pinkerton (CBE); **Research Staff:** Rachel Pollard, Parker Lewis

Research Area: *Health*



Ashley Han
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NYU TANDON SCHOOL OF ENGINEERING

Novel PHEMA-ylated Nanoparticles Assembled by Flash Nanoprecipitation for Pain Drug Delivery

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Pinkerton

BACKGROUND

- Nanoparticle surface chemistries dictate their behavior *in vivo*. Exploration of new and uncharacterized materials is needed to optimize nanoparticle-cell interactions.
- Poly(hydroxyethyl methacrylate) Poly(HEMA) is a type of polymer used for nanoparticle synthesis. Past experiments determined optimal chain length to be 3K.
- Determining the cytotoxicity of nanoparticles lays the foundation for their prospective applications with neurons, which is essential for comprehending their potential in pain therapeutic applications.

OBJECTIVES

1. Synthesize Poly(hydroxyethyl methacrylate) (PolyHEMA)-b-poly(D,L, lactic acid) block co-polymer.
2. Determine effect of different core material on PHEMA nanoparticle formation.
3. Determine the cytotoxicity of the nanoparticles on F11 cell line neurons.

METHODS

Figure 1. Flash Nanoprecipitation Schematic. The assembly of nanoparticles through the flash nanoprecipitation process. Various sizes were achieved through different ratios of block copolymers to core material

Figure 2. CCK-8 Cytotoxicity Assay. The testing of nanoparticle cytotoxicity on neurons utilizing a tetrazolium salt.

METHODS & RESULTS

Figure 3. PHEMA Library. A. Chemical Structure of the synthesized Poly(HEMA)-PLA. Intensity-weighted size distributions of Nanoparticles with block copolymer PHEMA measured by dynamic light scattering. Size increases with increasing **B.** Core (PEG), **C.** Encapsulation of Rubrene, and **D.** Encapsulation of Vitamin E.

Figure 4. F11 Neurons. A. Neuronal cell images under confocal stained with DAPI, NeuN, PGP9.5. Cytotoxicity of PHEMA nanoparticles encapsulated with vitamin E observed by microplate reader based on absorbance after **B.** 4 hours and **C.** 24 hours.

CONCLUSIONS & FUTURE WORK

- Poly(HEMA)-PLA block copolymer was synthesized and successfully formed nanoparticles.
- Different core materials were successfully encapsulated within the nanoparticles.
- The PHEMA nanoparticles were not cytotoxic after 24 hours of incubation.
- We suspect a nanoparticle-neuron interaction of cellular uptake and subsequent exocytosis, which may contribute to the observed increase in cell viability.

Future Work:

- Morphological assessment through TEM imaging of nanostructures
- Uptake studies to provide further evidence and insights into the nanoparticle-neuron interaction as well as rate of association and colocalization with subcellular components. .
- Conduct single nanoparticle tracking experiments to gain information about various aspects of intracellular dynamics such as the mechanisms of nanoparticle uptake and their intracellular trafficking.

Figure 5: Nano-Neuro Interaction. The diagram depicts the different approaches to nanoparticle and neuron interactions that will be explored: uptake and single particle tracking.

ACKNOWLEDGEMENTS

Support from the Undergraduate Summer Research Program (UGSRP). Cell culture studies done at NYU School of Dentistry (Jensen/Bunnett Lab). Images were created using Bio Render.

OPTIMIZING THE DIFFERENTIATION OF GENETICALLY MODIFIED INDUCED PLURIPOTENT STEM CELLS TO DENDRITIC CELLS

Dendritic cells (DCs) are antigen-presenting immune cells that initiate the adaptive immune response by secreting inflammatory cytokines, engulfing pathogens, and activating T-cells. Due to these properties, DCs have the potential to play a transformative role in immunotherapies by activating specific immune responses against infectious diseases and cancers. Current methods to produce DCs include harvesting them directly from patients or through extraction and differentiation of monocytes. Given that DCs represent less than 1% of circulating peripheral blood mononuclear cells, such methods have been limited by the inability to produce high-quality DCs on a larger-scale within reasonable time frames. Our new approach seeks to generate accessible "off-the-shelf" DCs from induced pluripotent stem cells (iPSCs), which are an unlimited resource, by using genetically engineered inducible gene circuits that force the cells directly into DCs through increased expression of three DC-specific genes. These gene circuits were integrated into the genome using CRISPR/Cas9. The primary goal of our research has been to optimize the function of these gene circuits by testing various cell media conditions and using varying concentrations of the antibiotic doxycycline to activate the circuit's Tet-On 3G inducible expression system. In order to monitor the differentiation of the cells, we assessed gene expression using quantitative PCR analysis by extracting RNA from cell samples at different time points after induction over the course of eight days. We also used fluorescent microscopy to observe cell morphology changes such as the development of dendrites and a more rounded cell shape. In the future, we aim to generate "programmable" DCs that can be used for further applications in regenerative medicine, including cancer therapies and treatments for Alzheimer's disease.

Project Supervisor: David Truong (BME); **Research Staff:** Minjoo Kim, Serena Francesca Generoso, Sarah Levovitz

Research Area: *Health*



Brianna Williams
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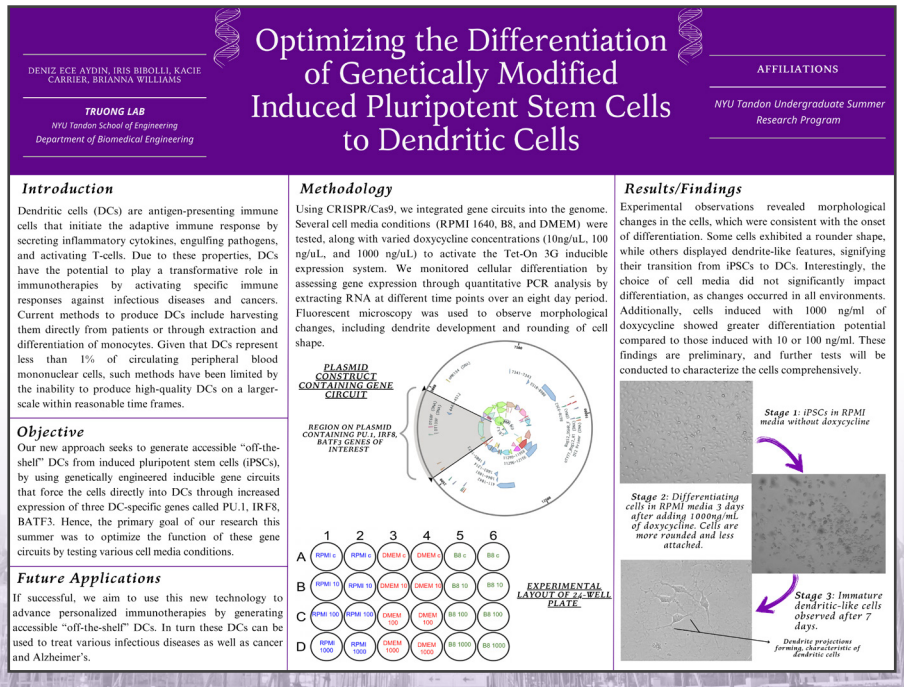
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Optimizing the Differentiation of Genetically Modified Induced Pluripotent Stem Cells to Dendritic Cells

DENIZ ECE AYDIN, IRIS BIBOLLI, KACIE CARRIER, BRIANNA WILLIAMS

TRUONG LAB
NYU Tandon School of Engineering
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AFFILIATIONS
NYU Tandon Undergraduate Summer Research Program

Introduction

Dendritic cells (DCs) are antigen-presenting immune cells that initiate the adaptive immune response by secreting inflammatory cytokines, engulfing pathogens, and activating T-cells. Due to these properties, DCs have the potential to play a transformative role in immunotherapies by activating specific immune responses against infectious diseases and cancers. Current methods to produce DCs include harvesting them directly from patients or through extraction and differentiation of monocytes. Given that DCs represent less than 1% of circulating peripheral blood mononuclear cells, such methods have been limited by the inability to produce high-quality DCs on a larger-scale within reasonable time frames.

Objective

Our new approach seeks to generate accessible "off-the-shelf" DCs from induced pluripotent stem cells (iPSCs), by using genetically engineered inducible gene circuits that force the cells directly into DCs through increased expression of three DC-specific genes called PU.1, IRF8, BATF3. Hence, the primary goal of our research this summer was to optimize the function of these gene circuits by testing various cell media conditions.

Future Applications

If successful, we aim to use this new technology to advance personalized immunotherapies by generating accessible "off-the-shelf" DCs. In turn these DCs can be used to treat various infectious diseases as well as cancer and Alzheimer's.

Methodology

Using CRISPR/Cas9, we integrated gene circuits into the genome. Several cell media conditions (RPMI 1640, B8, and DMEM) were tested, along with varied doxycycline concentrations (10ng/uL, 100 ng/uL, and 1000 ng/uL) to activate the Tet-On 3G inducible expression system. We monitored cellular differentiation by assessing gene expression through quantitative PCR analysis by extracting RNA at different time points over an eight day period. Fluorescent microscopy was used to observe morphological changes, including dendrite development and rounding of cell shape.

PLASMID CONSTRUCT CONTAINING GENE CIRCUIT

REGION ON PLASMID CONTAINING PU.1, IRF8, BATF3 GENES OF INTEREST

EXPERIMENTAL LAYOUT OF 24-WELL PLATE

Results/Findings

Experimental observations revealed morphological changes in the cells, which were consistent with the onset of differentiation. Some cells exhibited a rounder shape, while others displayed dendrite-like features, signifying their transition from iPSCs to DCs. Interestingly, the choice of cell media did not significantly impact differentiation, as changes occurred in all environments. Additionally, cells induced with 1000 ng/ml of doxycycline showed greater differentiation potential compared to those induced with 10 or 100 ng/ml. These findings are preliminary, and further tests will be conducted to characterize the cells comprehensively.

Stage 1: iPSCs in RPMI media without doxycycline

Stage 2: Differentiating cells in RPMI media 3 days after adding 1000ng/mL of doxycycline. Cells are more rounded and less attached.

Stage 3: Immature dendritic-like cells observed after 7 days.

Dendrite projections forming, characteristic of dendritic cells

PANCREATIC CANCER ORGANOIDS-ON-A-CHIP TO RECAPITULATE THE IN VIVO TUMOR MICROENVIRONMENT

Pancreatic ductal adenocarcinoma (PDAC) is a highly aggressive and lethal cancer that accounts for over 90% of pancreatic cancer cases. Modulation of the tumor microenvironment (TME) in PDAC via its hallmarks of stromal desmoplasia and high immunosuppression contribute to resistance to drugs and immunotherapies, leading to a high mortality rate in turn. Accordingly, a system that can replicate the PDAC TME becomes increasingly necessary. We integrate organ-on-a-chip technologies with organoids in order to develop a system that recapitulates the in vivo PDAC TME. Patient-derived organoids (PDOs) are able to simulate the function and structure of their in vivo counterparts with high fidelity, while organ-on-a-chip techniques offer precise experimental control and reproducibility. Soft lithography was used to fabricate microfluidic chips, on which PDOs were cultured. We reproduced the hypovascularity of the PDAC stromal niche on chip. Furthermore, when comparing the niche in PDAC organoids-on-a-chip with normal pancreatic organoids-on-a-chip, we observed characteristics of desmoplasia and pro-tumor immunosuppression. Our proposed organoid-on-a-chip system thus recapitulates the PDAC TME and is promising as a platform to study the mechanism of drug resistance in PDAC as well as testing novel therapies.

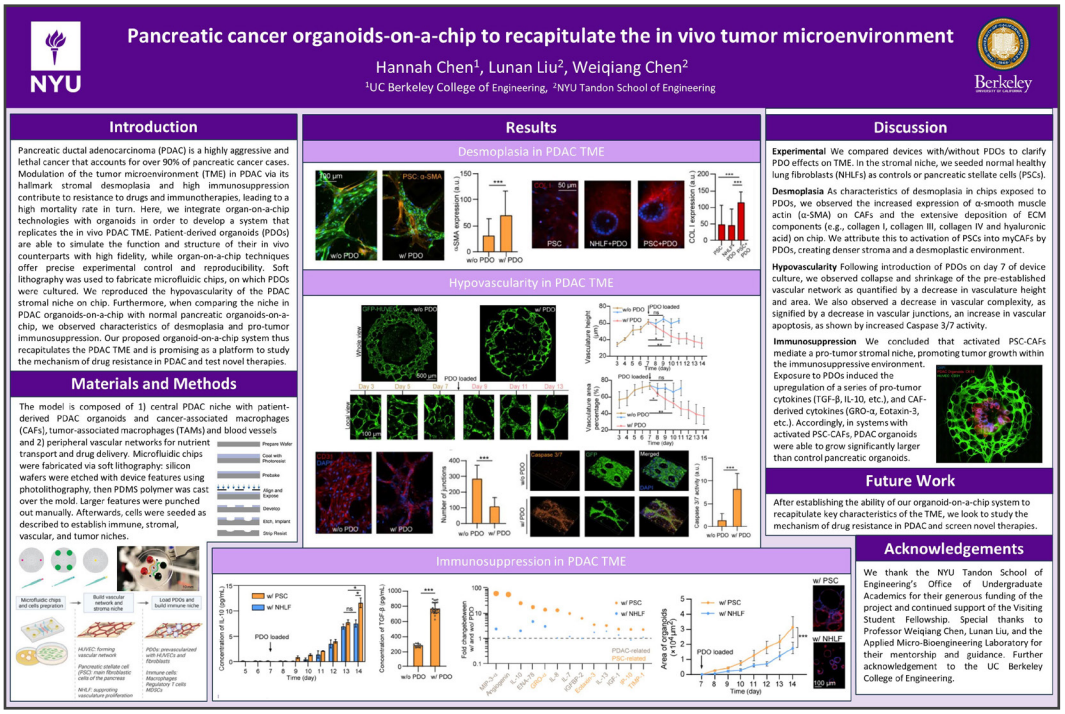
Project Supervisor: Weiqiang Chen (BME, MAE); **Research Staff:** Lunan Liu

Research Area: *Health*



Hannah Chen
Materials Science and Engineering, 2026
University of California, Berkley

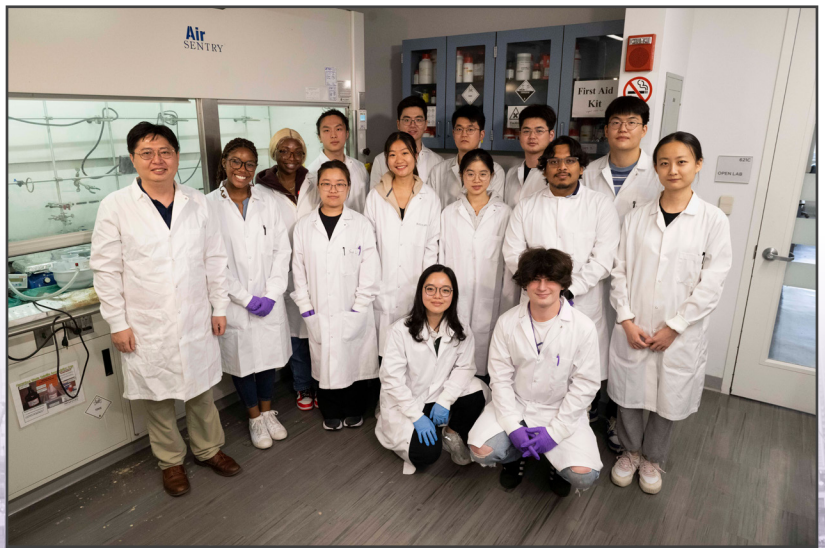
Visiting Student Fellow





Hannah Chen and the fabricated organ-on-chip devices

Professor Chen's Lab. *From Left to Right:* Professor Chen, Sandra, Djamila, Brandon, Lunan, Fanghao, Chao, Shuhao, Sue, Hannah, Jingwei, Neil, Huishu, Kate, Milo



THE ROLE OF THE PERICELLULAR MATRIX IN JOINT INFLAMMATION AND REPAIR

Damaged cartilage in joints often causes pain and despite advanced surgical procedures intended to repair the tissue, challenges still persist. The main concern is the formation of fibrocartilage instead of hyaline cartilage at the repair site. The initial phase after injury is an inflammatory phase characterized by the abundance of pro-inflammatory M1 macrophages at the injury site, followed by a remodeling phase in which anti-inflammatory M2 macrophages play a key role. M1 macrophage polarization is activated by interferon-gamma (IFN-γ) and lipopolysaccharide (LPS), while polarization into anti-inflammatory M2 macrophages can be activated by interleukin (IL)-4 and IL-13. A main problem after cartilage and other joint injuries is that M1 macrophages persist, leading to chronic inflammation and pain. Receptor for hyaluronan-mediated motility (RHAMM) interactions with hyaluronan (HA) promotes macrophage migration to the injury site and promotes macrophage polarization into inflammatory M1 macrophages. We hypothesized that interfering with HA/RHAMM interactions using a RHAMM mimetic peptide (P15-1) will reduce inflammation after joint injury via the inhibition of M1 macrophage polarization. Our findings showing that P15-1 treatment reduced the expression of RHAMM and inflammatory markers in M1 macrophages support our hypothesis. Our findings suggest that interfering with HA/RHAMM interactions in macrophages may present a novel therapeutic strategy to improve joint tissue regeneration after injury.

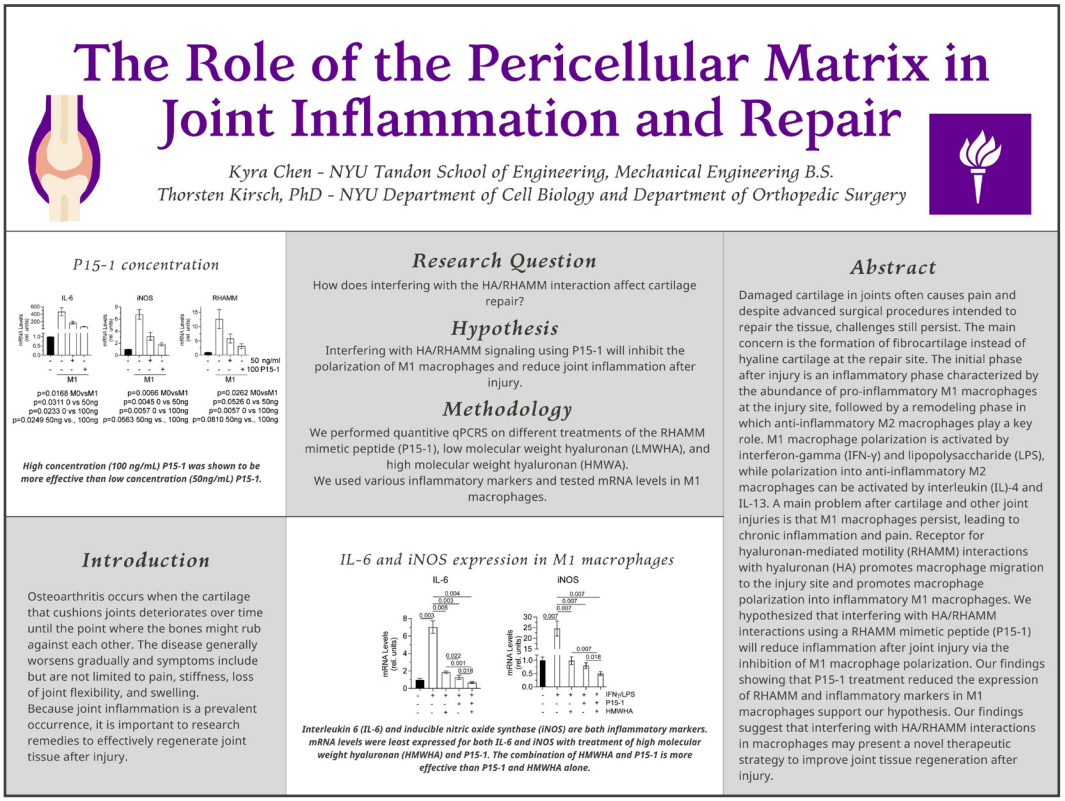
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Research Area: *Health*



Kyra Chen
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STUDY OF LASER-INDUCED CRYSTALLIZATION USING MICROFLUIDIC DEVICES

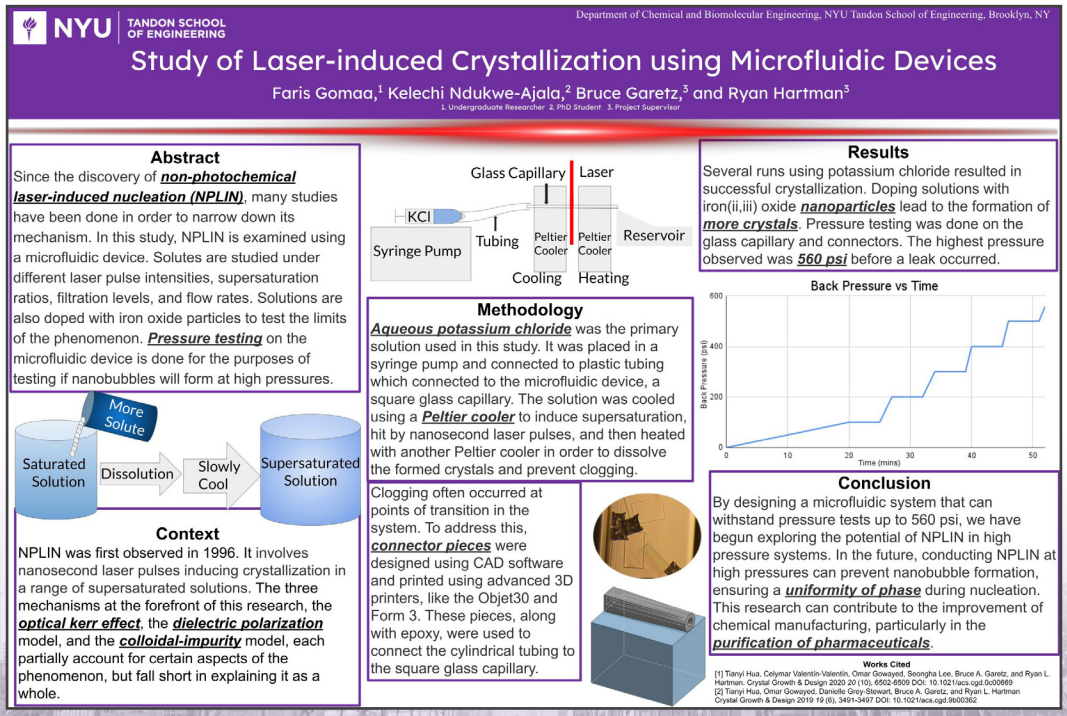
Non-photochemical laser-induced nucleation (NPLIN), a phenomenon first observed in 1996, involves nanosecond laser pulses inducing crystallization in a range of supersaturated solutions. Since its discovery, many studies have been done in order to narrow down the mechanism behind NPLIN. The three mechanisms at the forefront of this research – the optical Kerr effect, the dielectric polarization model, and the colloidal-impurity model – each partially account for certain aspects of the phenomenon, but fall short in explaining it as a whole. In this study, NPLIN is examined using a microfluidic device, which provides several advantages, including a decreased chance of contamination, more potential supersaturation levels to test, an increased level of control, and quicker retrieval and analysis of data. Using this microfluidic device, solutes such as potassium chloride are studied under different laser pulse intensities, supersaturation ratios, filtration levels, and flow rates. Solutions are also doped with iron oxide impurity particles to test the limits of the phenomenon. Lastly, pressure testing on the microfluidic device is done in an effort to eventually test nanobubble formation at high pressures. These results are analyzed in order to better characterize the mechanism behind the phenomenon, which has uses in chemical manufacturing, such as in the production of pharmaceuticals, ensuring their purification and allowing for better control of the physical attributes of the products.

Project Supervisor: Bruce Garetz (CBE); **Research Staff:** Kelechi Ndukwe-Ajala, Ryan Hartman

Research Areas: *Health, Sustainability*



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THERMORESPONSIVE PROTEIN-ENGINEERED HYDROGELS FOR THE DELIVERY OF HYDROPHOBIC CARTILAGE THERAPEUTIC DRUG KARTOGENIN

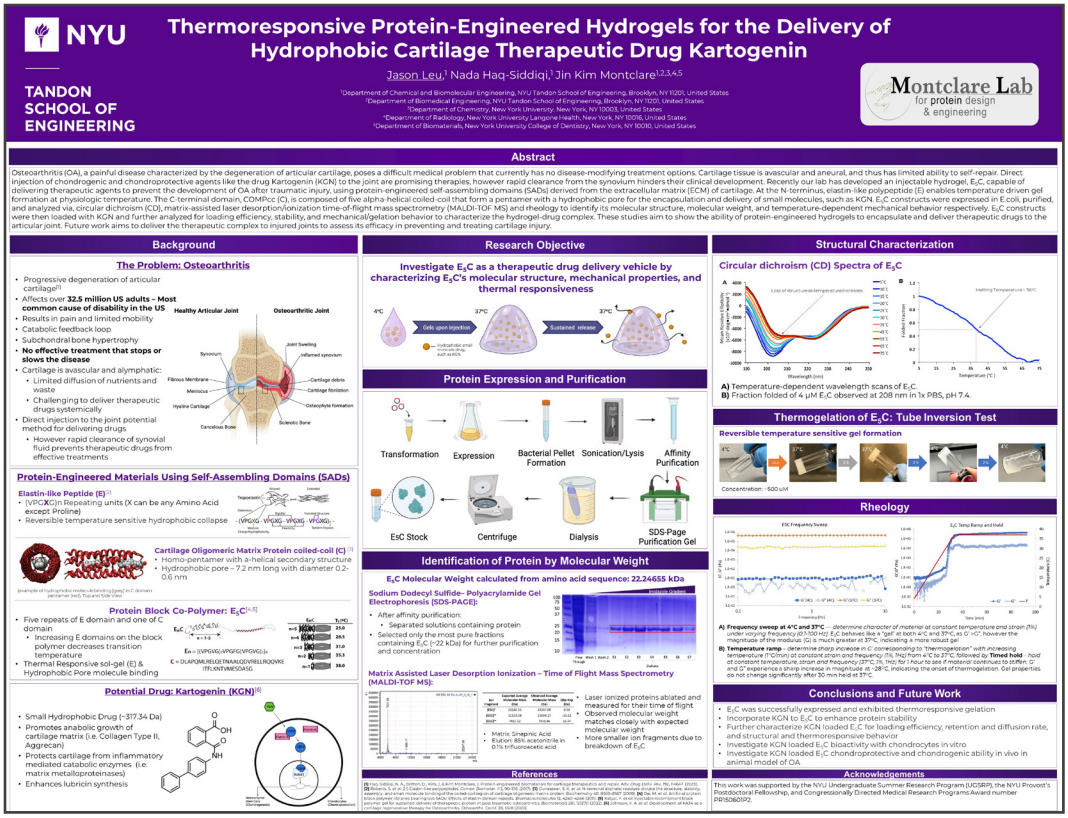
Osteoarthritis (OA), a painful disease characterized by the degeneration of articular cartilage, poses a difficult medical problem that currently has no disease-modifying treatment options. Cartilage tissue is avascular and aneural, and thus has limited ability to self-repair. Direct injection of chondrogenic and chondroprotective agents like the drug Kartogenin (KGN) to the joint are promising therapies, however rapid clearance from the synovium hinders their clinical development. Recently our lab has developed an injectable hydrogel, E5C, capable of delivering therapeutic agents to prevent the development of OA after traumatic injury, using protein-engineered self-assembling domains (SADs) derived from the extracellular matrix (ECM) of cartilage. At the N-terminus, elastin-like polypeptide (E) enables temperature driven gel formation at physiologic temperature. The C-terminal domain, COMPcc (C), is composed of five alpha-helical coiled-coil that form a pentamer with a hydrophobic pore for the encapsulation and delivery of small molecules, such as KGN. E5C constructs were expressed in E.coli, purified, and analyzed via, circular dichroism (CD), matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) and rheology to identify its molecular structure, molecular weight, and temperature-dependent mechanical behavior respectively. E5C constructs were then loaded with KGN and further analyzed for loading efficiency, stability, and mechanical/gelation behavior to characterize the hydrogel-drug complex. These studies aim to show the ability of protein-engineered hydrogels to encapsulate and deliver therapeutic drugs to the articular joint. Future work aims to deliver the therapeutic complex to injured joints to assess its efficacy in preventing and treating cartilage injury.

Project Supervisor: Jin Montclare (CBE); **Faculty Mentor:** Nada Haq-Siddiqi

Research Area: *Health*



Jason Leu
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16S METAGENOMICS SEQUENCING STUDIES

The effects of climate change include a sequence of events that are all significantly associated with waterborne diseases, including heavy rainfall patterns, flooding, and hot weather. These atypical weather and temperature patterns contribute to an increased risk of contracting a waterborne disease, especially bacterial in nature, through recreational and environmental activities. The 16S ribosomal RNA (rRNA) genetic region is approximately 1600 base pairs long with nine hypervariable regions (V1-V9), that have varying levels of conservation. While more highly conserved regions are important to determine higher-ranking taxa, genus and species are determined through quickly changing regions. Water samples were collected from five lakes, rivers, and ponds around New Jersey. These were from primarily recreational areas, where people are more likely to be exposed to potential waterborne pathogens due to activities such as fishing, rowing, or swimming. Following filtration using a Pall Microfilter and DNA Isolation using the Qiagen PowerWater Kit, the DNA samples undergo one round of PCR to amplify the V4 hypervariable region. This region was selected as it showed the best results for coverage, domain specificity, and a broad spectrum of bacteria. Finally, the PCR products are prepared to be sequenced, and the Illumina iSeq100 system is used to create a sequencing library. The library is then used to determine the bacteria present in each sample by comparing it to libraries of already sequenced genomes.

Project Supervisor: Nikita Grigoryev (CBE)

Research Area: *Health*



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NYU TANDON SCHOOL OF ENGINEERING

16S Metagenomics: Testing Water Microbiomes

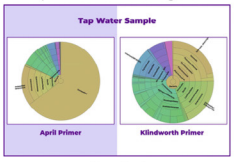
Aanya Subhedar, Professor Nikita Grigoryev
Department of Chemical and Biomolecular Engineering, NYU Tandon School of Engineering, Brooklyn, NY, USA

Abstract

The effects of climate change include a sequence of events that are all significantly associated with waterborne diseases, including heavy rainfall patterns, flooding, and hot weather. These atypical weather and temperature patterns contribute to an increased risk of contracting a waterborne disease, especially bacterial, through recreational and environmental activities. The 16S ribosomal RNA (rRNA) genetic region is approximately 1600 base pairs long with nine hypervariable regions (V1–V9) that have varying levels of conservation. While more highly conserved regions are important to determine higher-ranking taxa, the genus and species are determined through quickly changing regions. Water samples were collected from five lakes, rivers, and ponds around New Jersey. These were from primarily recreational areas, where people are more likely to be exposed to potential waterborne pathogens due to activities such as fishing, rowing, or swimming. Following filtration using a Pall Microfilter and DNA Isolation using the Qiagen PowerWater Kit, the DNA samples undergo one round of PCR to amplify the V4 hypervariable region. This region was selected as it has the potential to produce the best results for coverage, domain specificity, and a broad spectrum of bacteria. Finally, the PCR products are prepared to be sequenced, and the Illumina iSeq100 system is used to create a sequencing library. The library is then used to determine the bacteria present in each sample by comparing it to libraries of already sequenced genomes.

Background

16S metagenomics involves sequencing the highly conserved 16S rRNA gene, which is used to study microbial diversity. Studies involving 16S metagenomics typically provide insights into the genetic makeup of a microbial population, which ultimately allows for taxonomic identification and the exploration of the microbiomes of diverse environments. Within the 16S rRNA gene, certain hypervariable regions contain more genetic variation than others, which are frequently targeted in metagenomics studies. The high levels of variability provide finer taxonomic resolution, which allows one to better differentiate closely related species within a sample. Different hypervariable regions' ability to provide better taxonomic resolution or coverage are tested through the use of PCR and primers that target the amplification of these regions.

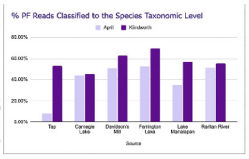


Methodology

About 100-150 mL of "dirty" water samples were collected from five different rivers and lakes, and 500 mL of tap water was used as a baseline. Two different V4 primers were used, as the V4 region was a focus of the study – April and Klindworth.

Data/Observations

Both April and Klindworth Primers showed general success in the sequencing study, indicating that the V4 hypervariable region may be optimal, possibly in conjunction with another region. Between the two primers, however, the Klindworth primer showed consistently better results in terms of specificity, as shown in the bar chart to the right, where Klindworth Primers had a greater % PF (pass-filter) read in every sample, which serves as an indication of a successful, specific, and reliable read. Additionally, the tap water sample results, which were intended to serve as a baseline, showed bacterial DNA, which indicates DNA fragments in the sample, and must be studied further to determine the source.



Conclusion and Future Applications

The Klindworth V4 Primers provided better coverage and specificity when compared to the April V4 Primers. The type of water body seemed to have a correlation with the types of bacteria found in each sample, but further studies with a wide variety of samples must be conducted to verify this. As this was a pilot study, there are multiple avenues of exploration that have opened up following the analysis of these results. This includes conducting further studies on the tap water to determine the source of the bacterial DNA identified.

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.

FACULTY

Joseph Chow (CUE)
Ryan Hartman (CBE)
Jin Ryoun Kim (CBE)
Miguel Modestino (CBE)
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LEARN MORE

ADVANCED 3D MODELING & MULTIPHYSICS SIMULATION ON ENGINEERING PILOT APPARATUS

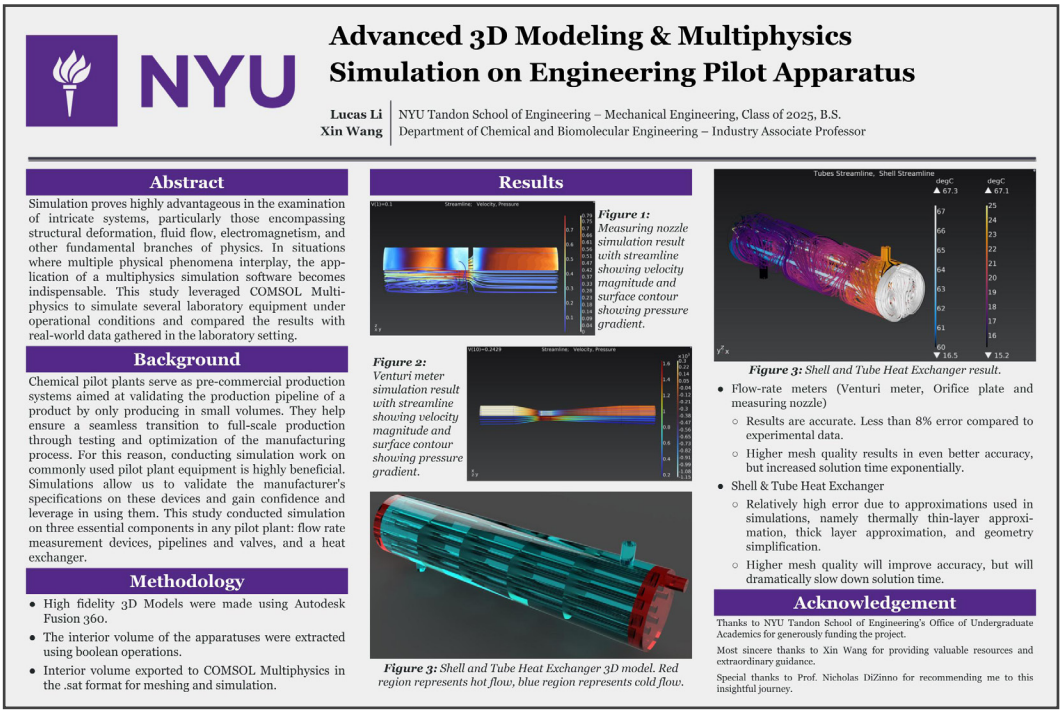
Pilot plants play a vital role in validating emerging production technologies and ensuring a seamless transition to full-scale commercial production. To engineer highly efficient pilot plants, the integration of advanced multiphysics simulation software is imperative. Unlike dedicated simulation software limited to specific physics disciplines, multiphysics software amalgamates diverse physics phenomena into a single cohesive study, which more closely aligns with real-world scenarios where various interactions occur. This research project focuses on developing precise 3D models for common laboratory apparatus, including flow rate meters such as orifice plate devices and venturi meters, pipelines, and a heat exchanger, utilizing Fusion 360. Subsequently, comprehensive simulations of these devices are conducted under realistic working conditions using COMSOL Multiphysics. Encompassing fluid dynamics (CFD), heat transfer, and chemical reactions, the simulations foster a profound understanding of the system's behavior. This study aims to achieve a high degree of accuracy in matching simulation data with experimental data. This alignment will enable the engineering of pilot plants and similar devices that meet expectations and provide insights into potential design features for optimization.

Project Supervisor: Xin Wang (CBE); **Research Staff:** Yuxiang Gao

Research Areas: *Sustainability, Health, Urban*



Jiaxuan (Lucas) Li
Mechanical Engineering, B.S., 2025
NYU Tandon School of Engineering



NYU

Advanced 3D Modeling & Multiphysics Simulation on Engineering Pilot Apparatus

Lucas Li | NYU Tandon School of Engineering – Mechanical Engineering, Class of 2025, B.S.
Xin Wang | Department of Chemical and Biomolecular Engineering – Industry Associate Professor

Abstract

Simulation proves highly advantageous in the examination of intricate systems, particularly those encompassing structural deformation, fluid flow, electromagnetism, and other fundamental branches of physics. In situations where multiple physical phenomena interplay, the application of a multiphysics simulation software becomes indispensable. This study leveraged COMSOL Multiphysics to simulate several laboratory equipment under operational conditions and compared the results with real-world data gathered in the laboratory setting.

Background

Chemical pilot plants serve as pre-commercial production systems aimed at validating the production pipeline of a product by only producing in small volumes. They help ensure a seamless transition to full-scale production through testing and optimization of the manufacturing process. For this reason, conducting simulation work on commonly used pilot plant equipment is highly beneficial. Simulations allow us to validate the manufacturer's specifications on these devices and gain confidence and leverage in using them. This study conducted simulation on three essential components in any pilot plant: flow rate measurement devices, pipelines and valves, and a heat exchanger.

Methodology

- High fidelity 3D Models were made using Autodesk Fusion 360.
- The interior volume of the apparatuses were extracted using boolean operations.
- Interior volume exported to COMSOL Multiphysics in the .sat format for meshing and simulation.

Results

Figure 1: *Measuring nozzle simulation result with streamline showing velocity magnitude and surface contour showing pressure gradient.*

Figure 2: *Venturi meter simulation result with streamline showing velocity magnitude and surface contour showing pressure gradient.*

Figure 3: *Shell and Tube Heat Exchanger 3D model. Red region represents hot flow, blue region represents cold flow.*

Figure 3: *Shell and Tube Heat Exchanger result.*

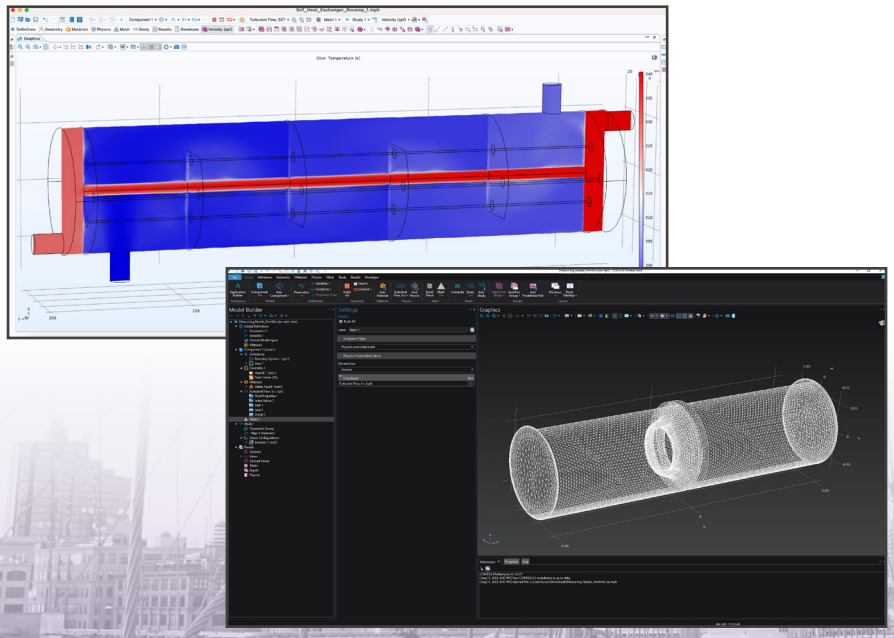
- Flow-rate meters (Venturi meter, Orifice plate and measuring nozzle)
  - Results are accurate. Less than 8% error compared to experimental data.
  - Higher mesh quality results in even better accuracy, but increased solution time exponentially.
- Shell & Tube Heat Exchanger
  - Relatively high error due to approximations used in simulations, namely thermally thin-layer approximation, thick layer approximation, and geometry simplification.
  - Higher mesh quality will improve accuracy, but will dramatically slow down solution time.

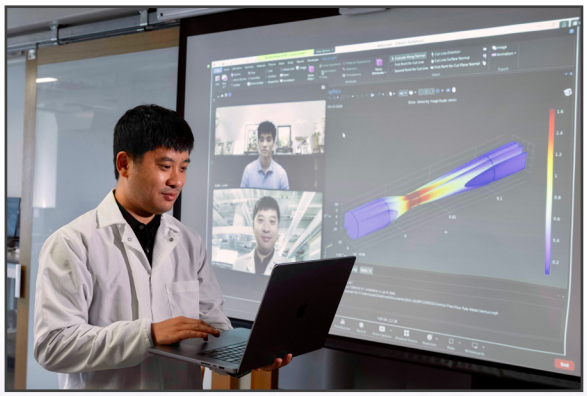
Acknowledgement

Thanks to NYU Tandon School of Engineering's Office of Undergraduate Academics for generously funding the project.

Most sincere thanks to Xin Wang for providing valuable resources and extraordinary guidance.

Special thanks to Prof. Nicholas DiZinno for recommending me to this insightful journey.





Prof. Wang and Lucas Li meeting remotely for a simulation project powered by COMSOL Multiphysics® on Fluid Dynamics in Chemical Engineering

SUSTAINABILITY

FARADAIC EFFICIENCY OF ELECTROCHEMICALLY OXIDIZED NICKEL DITHIOLENE COMPLEXATION WITH OLEFIN MOLECULES

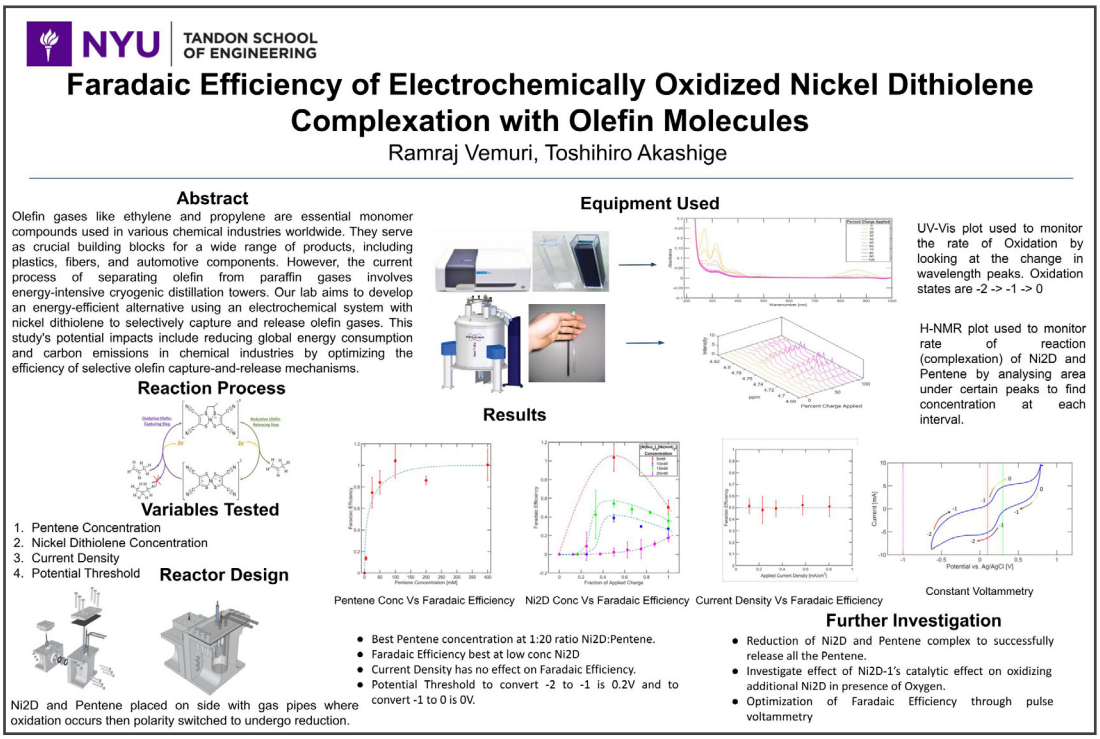
Olefin gases, such as ethylene and propylene, are vital compounds used in diverse chemical industries worldwide. They serve as essential building blocks for a wide array of products, ranging from plastics and fibers to automotive components and pharmaceuticals. However, the current process of obtaining olefins from paraffin gases involves energy-intensive cryogenic distillation towers. To address this issue, our lab is researching energy-efficient alternatives for olefin/paraffin separation. Previous work demonstrated the successful separation of propylene from propane using an electrochemical system with nickel dithiolene. This novel approach selectively captures and releases olefin gases through pi-bonding complexation. The ongoing study focuses on the complexation process between nickel maleonitriledithiolate and 1-pentene in a liquid environment. By understanding how various parameters, such as nickel dithiolene concentration, current density, and electrochemical potential, affect the Faradaic efficiency and material utilization fraction, we aim to optimize the efficiency of selective olefin capture-and-release mechanisms. This research has the potential to significantly impact the chemical industry. By eliminating the need for energy-intensive cryogenic distillation towers, the process could reduce global energy consumption related to olefin/paraffin separation. Additionally, it may lead to decreased carbon emissions associated with fossil fuel burning during separation processes. In conclusion, the study of nickel dithiolene's efficiency in olefin capture-and-release is a promising step towards more sustainable and energy-efficient practices in the chemical industry.

Project Supervisor: Miguel Modestino (CBE); **Research Staff:** Toshihiro Akashige

Research Area: *Sustainability*



Ramraj Vemuri
Chemical and Biomolecular Engineering, B.S., 2024
NYU Tandon School of Engineering



NYU TANDON SCHOOL OF ENGINEERING

Faradaic Efficiency of Electrochemically Oxidized Nickel Dithiolene Complexation with Olefin Molecules

Ramraj Vemuri, Toshihiro Akashige

Abstract

Olefin gases like ethylene and propylene are essential monomer compounds used in various chemical industries worldwide. They serve as crucial building blocks for a wide range of products, including plastics, fibers, and automotive components. However, the current process of separating olefin from paraffin gases involves energy-intensive cryogenic distillation towers. Our lab aims to develop an energy-efficient alternative using an electrochemical system with nickel dithiolene to selectively capture and release olefin gases. This study's potential impacts include reducing global energy consumption and carbon emissions in chemical industries by optimizing the efficiency of selective olefin capture-and-release mechanisms.

Reaction Process

Variables Tested

1. Pentene Concentration
2. Nickel Dithiolene Concentration
3. Current Density
4. Potential Threshold

Reactor Design

Ni2D and Pentene placed on side with gas pipes where oxidation occurs then polarity switched to undergo reduction.

Equipment Used

UV-Vis plot used to monitor the rate of Oxidation by looking at the change in wavelength peaks. Oxidation states are -2 -> -1 -> 0

H-NMR plot used to monitor rate of reaction (complexation) of Ni2D and Pentene by analysing area under certain peaks to find concentration at each interval.

Results

Pentene Conc Vs Faradaic Efficiency | Ni2D Conc Vs Faradaic Efficiency | Current Density Vs Faradaic Efficiency | Constant Voltammetry

- Best Pentene concentration at 1:20 ratio Ni2D:Pentene.
- Faradaic Efficiency best at low conc Ni2D
- Current Density has no effect on Faradaic Efficiency.
- Potential Threshold to convert -2 to -1 is 0.2V and to convert -1 to 0 is 0V.

Further Investigation

- Reduction of Ni2D and Pentene complex to successfully release all the Pentene.
- Investigate effect of Ni2D-1's catalytic effect on oxidizing additional Ni2D in presence of Oxygen.
- Optimization of Faradaic Efficiency through pulse voltammetry

FLOODNET

Flooding has become an increasingly problematic issue along with the volatile precipitation in the era of climate change. For big-scale coastal cities like NYC, not only the problem of flooding is even more essential for its significant social impact but also harder to address because of the complexity of the geographical and structural environment. Given the importance and the lack of systematic documentation of floods in NYC, Floodnet aims to provide an accurate, unbiased, affordable, and publicly accessible flood monitoring platform by designing and deploying a network of low-cost flood-level ultrasonic sensors in various locations in NYC. The network consists of wireless solar-powered ultrasonic sensors deployed in flood-prone areas of the city whose data is gathered by nearby gateways and transferred to a centralized database. The data is then cleaned and processed by a machine-learning pipeline where apparent noises are filtered. As the sensor network gets larger, lapses among sensors are inevitable given the fickle nature of the environment which makes it requisite to track sensors' functioning status to maintain the sustainability of the network. By collecting and analyzing the sensor conditional data such as battery level and signal condition, we have been trying to discern anomalous behaviors of the sensors and detect sensor glitches and breakdowns, based on which we can build an automatic model to reveal and even predict sensor faults.

Project Supervisor: Andrea Silverman (CUE); **Research Staff:** Charlie Mydlarz

Research Areas: *Sustainability, Urban, Data Science/AI/Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Floodnet: Maintaining the Sensor Network

Ashok Timsina,[1] Xingji Jax Li[2]

1. NYU Abu Dhabi 2. NYU Shanghai

Abstract

With the aim of dealing with floods effectively in NYC, Floodnet has been building a network of flood sensors. As the sensor network gets larger, lapses among sensors is inevitable given the unstable nature of the environment. This makes it necessary to track network health and detect lapses to maintain the sustainability of the network.

Background on the Project

Flooding has become an increasingly problematic issue along with the volatile precipitation in the era of climate change. For coastal cities like New York City , not only the problem of flooding is even more essential for its significant social impact but also harder to address because of the complexity of the geographical and structural environment.



Figure 1: Flood due to Ida hurricane in NYC, 2021 [1]

Historically, data related to flood in New York City was collected based on community report. This is not efficient because someone has to witness the flood to report [2]. Floodnet is deploying a network of affordable, wireless solar-powered ultrasonic flood sensors in flood prone locations to detect flood and collect data about depth and duration of flooding events. Floodnet uses LoRaWAN technology for data transfer where the sensors transmit data to gateways which then forwards it to the centralized database. Each gateway is capable of connecting to different sensors and vice-versa (see Figure 2).

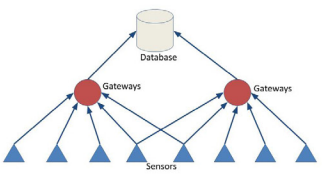


Figure 2: Structure of the data flow

Data Analysis

In order to monitor functioning of the sensor network, data related to sensor condition like battery voltage, network strength, and so on are collected, based on which our analysis focuses on identifying potential causes of sensor failures such as breakdowns and glitches.

Power and network are the two essential components for functioning of the sensor network. Our analysis showed that battery voltage can not indicate most of the sensor glitches(Figure 3) while Packet Success Rate(PSR) could be a better parameter for detecting sensor anomaly(see Figure 4 & 5).

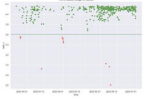


Figure 3: Failure during low battery voltage

Contrary to our assumption that low battery voltage was the reason for most of the sensor breakdowns for more than 1 hour, the analysis of data for past 3 months showed that most of the breakdowns for more than 1 hour occurred when battery voltage was in good cognition(above 3.6 volts) except some outliers which are below 3.6 volts.

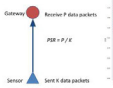


Figure 4: How PSR is calculated



Figure 5: Line plot for sensors with 'bad' PSR performance

Among more the 60 sensors in the analysis, more than 50 of them show a stable PSR with minimum greater than 50% in the interval from April to mid July 2023, though there exist problematic sensors (see Figure).

Future Work

Based on the analysis a autonomic process or a machine learning model could be built to detect and classify anomaly among the network for timely intervention.

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Acknowledgement

We would like to show unbounded gratitude to NYU Tandon's Office of Undergraduate Academics for this opportunity. Additionally, special thanks to our faculty Prof. Andrea Silverman and mentors Charlie, Praneeth and everyone in the team for patient guidance and support.

SUSTAINABILITY

INDIRECT PHOTODEGRADATION OF PESTICIDES

Pesticides serve a critical role in agriculture by increasing crop yields to secure food supply. Their extensive use makes them ubiquitous in the environment through runoff and industrial discharge. As inherently toxic chemicals, pesticides pose risks to non-target organisms and are potentially hazardous to humans. A potential degradation pathway of pesticides in the aquatic environment is indirect photodegradation, whereby naturally present dissolved organic matter (DOM) absorbs sunlight and produces reactive species. Our goal was to determine reaction rates of over twenty pesticides with two reactive species, singlet oxygen and triplet excited states, using model sensitizers as their sources. To validate whether different model sensitizers produce similar results and can be used to approximate reaction rates of reactive species with pesticides in DOM solutions, two were used as sources of singlet oxygen, and three of triplet excited states. Experiments were performed using a photoreactor with UVA bulbs, and the steady-state concentration of the reactive species were measured with probe compounds. Liquid chromatography quantified the degradation of the pesticides over time in pH 7 buffered solutions. Results showed that pesticides have different susceptibilities to react with the reactive species; while most pesticides did not degrade, triplet excited states caused more degradation than singlet oxygen. When degradation was observed, reaction rate constants could be determined, which can be applicable in predictive models of pesticides photodegradation in environmental systems. Further experiments should be performed in natural DOM solutions to evaluate whether these reaction rate constants are representative of pesticides' degradative behavior in the environment.

Project Supervisor: Andrea Silverman (CUE); **Research Staff:** Luana de Brito Anton

Research Areas: *Sustainability, Urban*

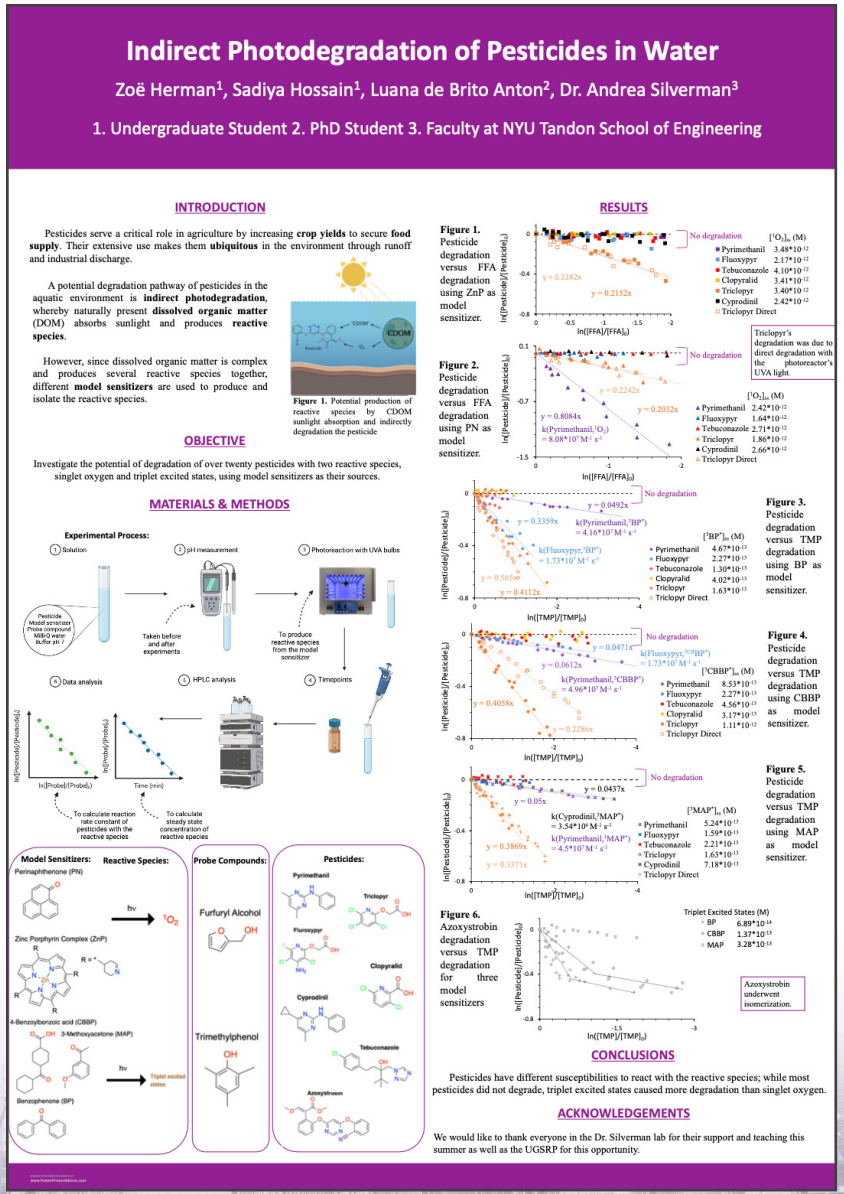


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SUSTAINABILITY

LIGHT INTERACTIONS WITH FAST CHARGING LITHIUM-ION BATTERY ELECTRODE

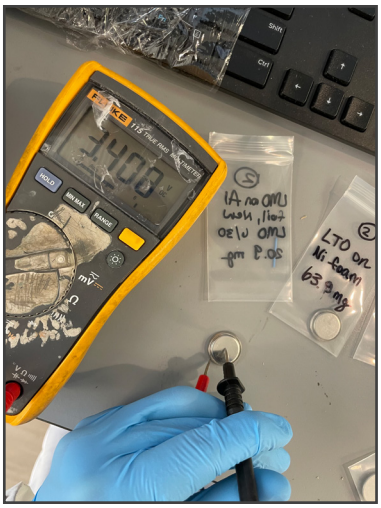
Lithium-ion batteries are the most popular and widely used batteries available in the market. Lithium's high energy density coupled with its cycling capabilities allow for this very efficient power source that we see in almost all our electronic devices we use in our daily lives. But what if there was a way to further increase the efficiency and performance of lithium-ion batteries? This research program explores the photo-acceleration effect of Lithium Manganese Oxide (LMO) cathodes, which results in faster charging of the electrode due to LMO's unique spinel crystal structure. When charging LMO normally, the passage of external current facilitates the oxidation of manganese atoms in the LMO, which shrinks its spinel structure resulting in the release of lithium cations and electrons. However, previous studies have shown that exposing LMO to electromagnetic radiation while it's charging also causes the oxidation of manganese. It has been observed that the radiation excites manganese electrons, turning them into free electrons and oxidizing the manganese (photo-oxidation), resulting in the further release of lithium cations and electrons (Lee, A., Vörös, M., Dose, W.M. et al., 2019). Therefore, the photo-oxidation of manganese coupled with the oxidation of manganese due to external current results in much faster charging speeds of the LMO electrode, called the photo-acceleration effect. This research program is conducted to exactly quantify this photo-acceleration effect by pairing the LMO cathode with a Lithium Titanium Oxide (LTO) anode, and altering the charging capacity of the LMO-LTO full cell battery, with goals of a full charge lasting up to 15 minutes.

Project Supervisor: André D. Taylor (CBE); **Research Staff:** Yaxin Shen

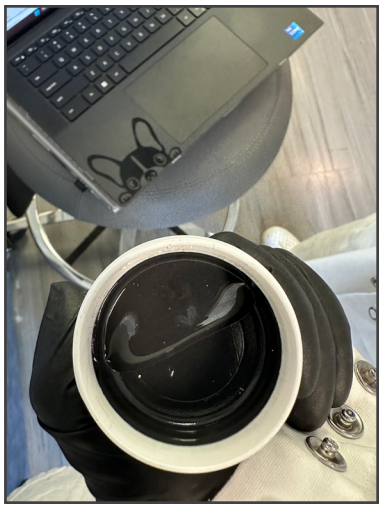
Research Area: *Sustainability*



Ariel Suynov
Chemical and Biomolecular Engineering, B.S., 2025
NYU Tandon School of Engineering



Output Voltage of Fresh LMO Coin Half Cell Before Galvanostatic Cycling



LMO Slurry Before Coating

NYU TANDON SCHOOL OF ENGINEERING

Electrode Development in Photo Assisted Fast Charging Lithium-Ion Batteries

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

1. Chemical and Biomolecular Engineering, Tandon School of Engineering

Abstract

Faster charging batteries are crucial nowadays, and recent studies have shown that LMO has special capabilities, allowing it to charge quicker with light illumination. The acceleration of delithiation in LMO is related to electron excitation, accompanied with lattice shrinkage. However, previous studies have used current collectors which induced high impedance in the cell due to the architecture of the electrode. To combat this problem, our research developed a new meshed electrode, capable of letting light penetrate through it and enhance its conductivity, for the purpose of photo-acceleration of charging.

Background

Faster charging batteries are a critical technology for the widespread adoption of electric vehicles (EVs). Photo-assisted fast charging technology provides an attractive approach regrading the demand of decarbonization. In 2019, C. Johnson reported that the charge rate of spinel $LiMn_2O_4$ (LMO) can be accelerated by the illumination of white light. They found that white light can induce a more oxidized metal center in LMO and hypothesized that the ejection of electrons accompanied with the oxidation of Mn increases the delithiation rate in the LMO structure.[1]

Later, J. Lipton reported that the fast charging of LMO depended on the wavelength of the illuminated light (photon energy). Specifically, they found that only 623nm red light generated the higher charge rate of LMO (Figure 1A), which accompanied the shrinkage of the Mn-Mn bond (Figure 1B, D). Based on this result they believe that the fast charging of LMO is related to the excitation of Mn electrons from the t_{2g} band to the e_g band, which has a band gap energy difference that matches the photon energy of red light (Figure 1C).[2]

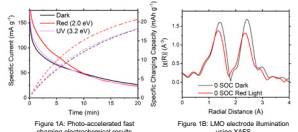


Figure 1A: Photo-accelerated fast charging electrochemical results

Figure 1B: LMO electrode illumination using XAFS

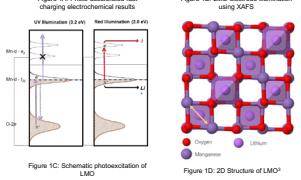
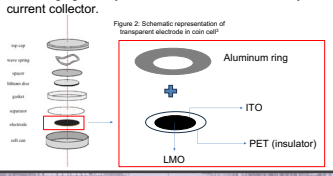


Figure 1C: Schematic photoexcitation of LMO

Figure 1D: 2D Structure of LMO[3]

However, the charge rate of the electrode is also limited by the poor conductivity of the transparent current collector (ITO on PET) and the unique connection to the coin cell case (Figure 2). In this research, we used Aluminum mesh to develop a new electrode design for the photo assisted fast charging battery and to enhance the conductivity of the current collector.

Figure 2: Schematic representation of transparent electrode in coin cell[4]



Methodology and Experiments

Electrodes were prepared by mixing LMO (80 wt%, MSE) with XC72 (10 wt%, MTI Corp) and PVDF binder (10 wt%, APV Engineered Coatings) in an N-Methyl-2-pyrrolidone (NMP, Alfa Aesar) slurry. The slurry was coated on Al mesh, and ITO/PET and dried at 80°C overnight.

Results

The uniform coating on the porous surface depends on the viscosity of the slurry and the amount of extra NMP added into the slurry. Additional 60 wt% of NMP can create a unform coating and 7-10 mg/cm² loading density on the mesh. (Figure 3A) With this electrode, the cell has small degradation and good efficiency at 0.1C galvanostatic cycling. (Figure 3B)

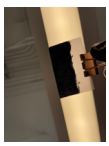


Figure 3A: Aluminum mesh electrode after drying

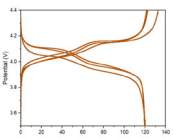


Figure 3B: Galvanostatic Cycle at 0.1C

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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 can go to others (Thompson-Bartlett, for instance).

OPTIMIZING β-GLUCOSIDASE ENZYMATIC ACTIVITY

β-Glucosidase is an enzyme, together with endo-glucanases and exo-glucanases, that breaks cellulose into glucose. This enzymatic process has diverse applications across food, agriculture, and biorefinery industries. In biorefinery processes, β-Glucosidase acts as a catalyst during saccharification, converting complex lignocellulosic biomass into glucose, which is further fermented into bioethanol. This project aims to enhance the enzymatic activity of β-Glucosidase by employing machine learning techniques to identify potential mutants with improved enzymatic efficiency. Machine learning models predict promising mutants with higher enzymatic activity based on the datasets with information about known enzymes and their activities. The selected mutants are then engineered through site-directed mutagenesis techniques. The evaluation of enzymatic performance involves monitoring 4-nitrophenyl levels using 4-Nitrophenyl β-D-glucopyranoside and a spectrometer, providing information about the enzymatic efficiency of the β-Glucosidase mutants. Through an iterative optimization approach guided by machine learning, the project aims to expedite the discovery of optimized mutants with desired characteristics, achieving enhanced efficiency while utilizing reduced resources.

Project Supervisor: Jin Ryoun Kim (CBE); **Research Staff:** Emre Erkanli

Research Areas: *Sustainability, Data Science/AI/Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Optimizing β-Glucosidase Activity through Machine Learning

Chaehyun Ryu, Mehmet Emre Erkanli, Jin Ryoun Kim
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Abstract

The objective of project is to enhance the enzymatic activity of β-Glucosidase through the application of machine learning. By analyzing datasets containing information on established enzymes and their enzymatic activities, the study aims to identify potential mutants that exhibit improved enzymatic efficiency. Subsequently, these mutants are synthesized and subjected to evaluation to find their enzymatic efficiency compared to the wild-type enzyme.

Introduction

β -glucosidase is a part of cellulase system, enzymes that metabolizes cellulose. Specifically, β-glucosidase degrades this oligosaccharides to glucose[1]. β-glucosidase is not only used on the biorefinery for cellulose degradation it is widely used in industry like food, brewery, cosmetics[2]. However, as glucose inhibits β-glucosidase and limits its activity, β-glucosidase often is a limiting factor for faster production.
To build mutant with higher enzymatic efficiency, Machine learning is used for the project to reduce the resource and time that will be needed for random mutagenesis.

Also, application of machine learning helps find patterns and structure in enzyme and simplifies rational design process as it helps identifying properties based on the patterns which will make the rational design process easier.

Methods

- Mutant with about 4 to 5 mutants per sequence were identified using Machine Learning
- E.coli cell was grown in Luria-Bertani (LB) broth and protein was expression and purified.
- Mutant analyzed in Spectrometer at 400nm at 70 with 4-Nitrophenyl β-D-glucopyranoside added.

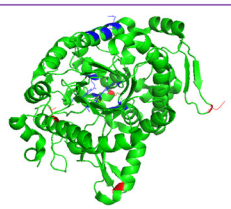


Figure 1: β-Glucosidase Model
The blue parts represents the binding site of the PfBGL and the red parts represents mutated parts based on the Machine Learning Mutant 1

Results

- PfBGL Wild Type $k_{cat}/K_m$was 961mMs^{-1}
- PfBGL Machine Learning Mutant(MLM)1 k_{cat}/K_m value was 1238 mMs^{-1}
- PfBGL MLM 2 k_{cat}/K_m was 627mMs^{-1}
- PfBGL MLM 3 k_{cat}/K_m was 369mMs^{-1}
- PfBGL MLM 4 k_{cat}/K_m was 227mMs^{-1}
- MLM 1 had higher enzymatic efficiency compared to wild type.

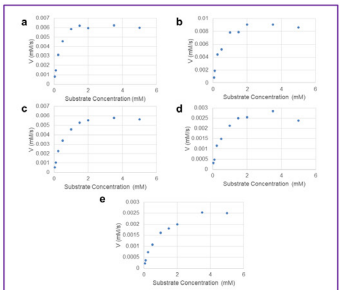


Figure 2: Michaelis-Menten Equation Graph for Wild Type and Machine Learning Mutants ***(a)*** *PfBGL Wild Type* ***(b)*** *PfBGL Machine Learning Mutant 1* ***(c)*** *PfBGL Machine Learning Mutant 2* ***(d)*** *PfBGL Machine Learning Mutant 3* ***(e)*** *PfBGL Machine Learning Mutant 4*

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[1] Singh G, Verma AK, Kumar V. Catalytic properties, functional attributes and industrial applications of β-glucosidases. 3 Biotech. 2016; Jun;6(1):3. doi: 10.1007/s13205-015-0328-z. Epub 2015 Dec 31. PMID: 28330074; PMCID: PMC4697909.
[2] Pros Kamran, Mohnaa Shafnoon M, Arunkeziti Bharathi Achudhan, Annapurna Gupta, Lilly M. Saleena, A review on applications of β-glucosidase in food, brewery, pharmaceutical and cosmetic industries, Carbohydrate Research, Volume 530, 2023, 108805, ISSN 0008-6215, https://doi.org/10.1016/j.carres.2023.108805.

SUSTAINABILITY

OPTIMIZATION OF SILVER SELENIDE VERTICAL DEVICES FOR HIGH SENSITIVITY NEAR INFRARED IMAGING

Near infrared imaging has promising potential applications including but not limited to detecting crop conditions, enabling night vision, and studying changing weather patterns. In the technology, colloidal quantum dots, which are semiconductor particles a few nanometers in size, are used as photodetectors, converting absorbed light in the range of 700 nm to 1600 nm into electrical current. In our work, we build silver selenide (Ag2Se) vertical devices, for its potential as a near infrared photodiode. By manipulating particle sizes, ligands, and particle deposition methods, we can alter the electrical properties of silver selenide. Photodiodes, which consist of hole and electron blocking layers interposed between the colloidal quantum dots layers, are built and measured. By evaluating the impact of each factor on the rise of conductivity and responsivity of the silver selenide photodiode, we aim to optimize Ag2Se vertical devices for high sensitivity near infrared imaging.

Project Supervisor/Faculty Mentor: Ayaskanta Sahu (CBE); **Research Staff:** Shlok Joseph Paul; Håvard Mølnås

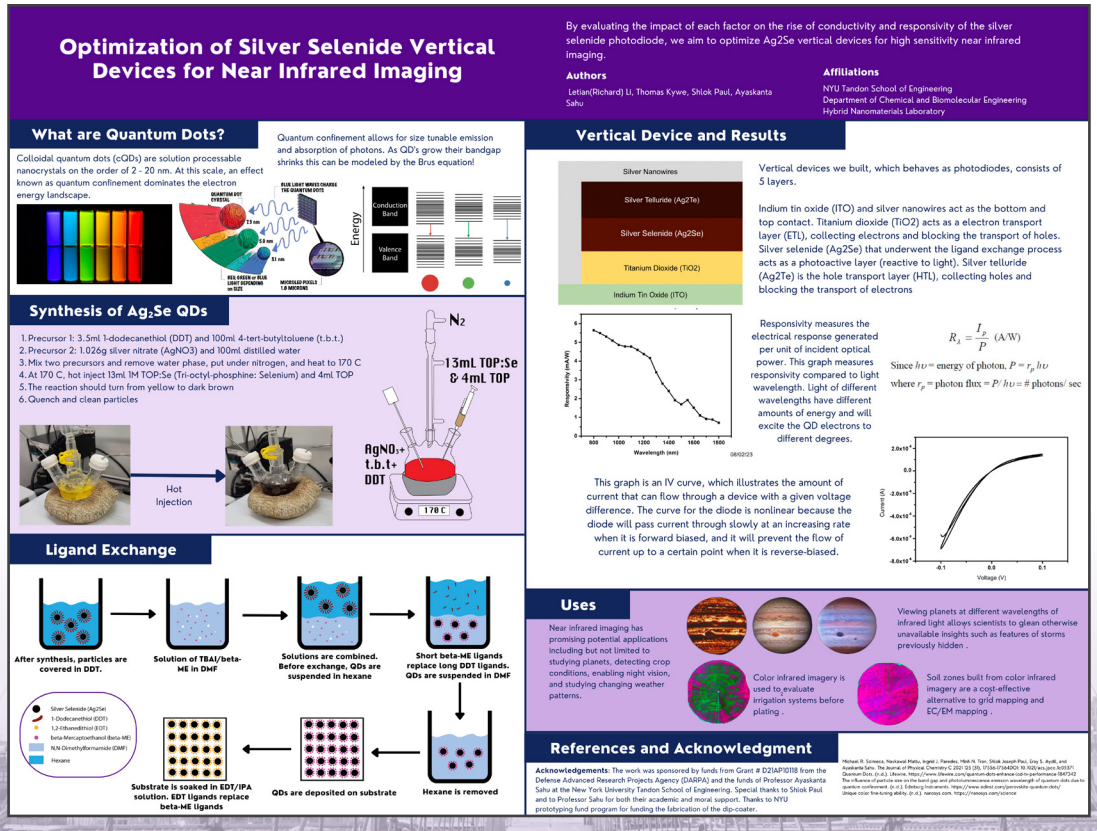
Research Area: *Sustainability*



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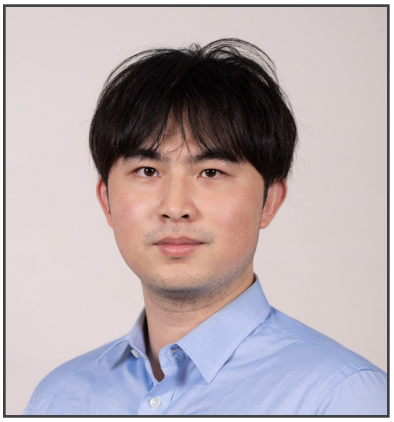
SUSTAINABILITY

PASCHEN CURVE SHIFTS IN GAS DISCHARGE TUBES DUE TO VARIOUS MAGNETIC FIELD AND GEOMETRIC CONFIGURATIONS

When a gas discharge tube (GDT) is subjected to an electric potential at or above its breakdown voltage, the gas particles inside undergo ionization due to the electric field, transforming it into a conductive plasma. Paschen curves depict this breakdown voltage as a function of the product of gas pressure and the separation distance between the two GDT electrodes. In this project, low-pressure GDTs were subjected to different magnetic field and tube geometry configurations. The GDTs were driven by a DC parallel RC circuit and the effects of the configurations on breakdown voltage were investigated. For each tube configuration, we measured and plotted its Pachen curve. Results indicate that a perpendicular magnetic field increases breakdown voltage before and decreases breakdown voltage after a point on the Paschen curve, and the tube length d divided by the radius r ratio resulted in a rightward shift of the paschen curve as the d/r ratio increased. Effects of the perpendicular magnetic field were found to have the same general relationship with the Paschen curve regardless of the d/r ratio, and the closer a perpendicular magnet to the tube the stronger the effect.

Project Supervisor: David Mugglin (Physics)

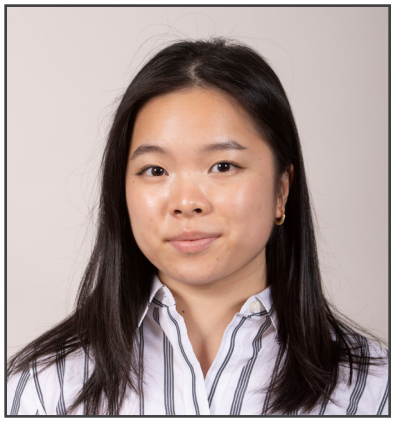
Research Area: *Sustainability*



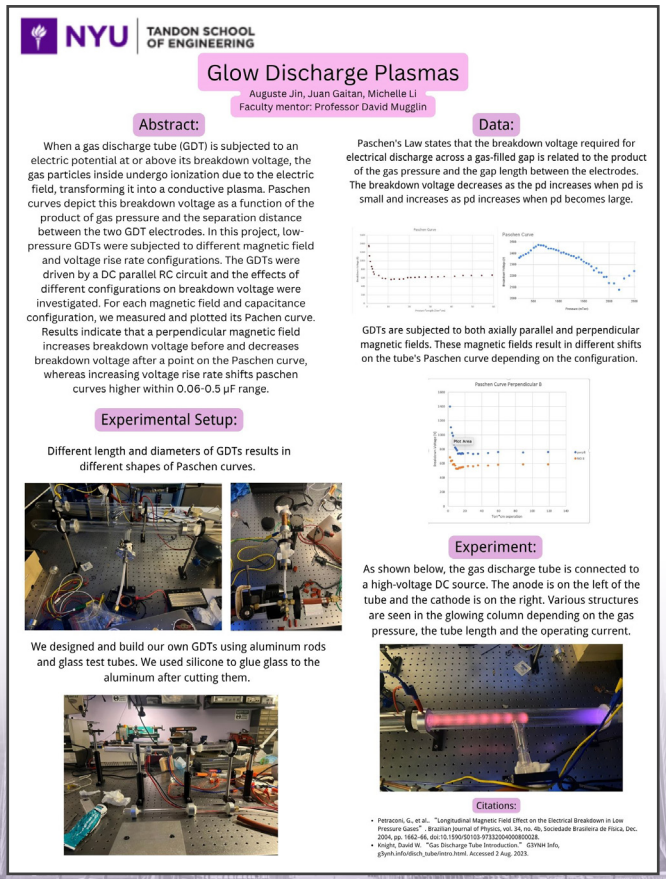
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NYU TANDON SCHOOL OF ENGINEERING

Glow Discharge Plasmas

Auguste Jin, Juan Gaitan, Michelle Li
Faculty mentor: Professor David Mugglin

Abstract:

When a gas discharge tube (GDT) is subjected to an electric potential at or above its breakdown voltage, the gas particles inside undergo ionization due to the electric field, transforming it into a conductive plasma. Paschen curves depict this breakdown voltage as a function of the product of gas pressure and the separation distance between the two GDT electrodes. In this project, low-pressure GDTs were subjected to different magnetic field and voltage rise rate configurations. The GDTs were driven by a DC parallel RC circuit and the effects of different configurations on breakdown voltage were investigated. For each magnetic field and capacitance configuration, we measured and plotted its Pachen curve. Results indicate that a perpendicular magnetic field increases breakdown voltage before and decreases breakdown voltage after a point on the Paschen curve, whereas increasing voltage rise rate shifts paschen curves higher within 0.06-0.5 μF range.

Experimental Setup:

Different length and diameters of GDTs results in different shapes of Paschen curves.

We designed and build our own GDTs using aluminum rods and glass test tubes. We used silicone to glue glass to the aluminum after cutting them.

Data:

Paschen's Law states that the breakdown voltage required for electrical discharge across a gas-filled gap is related to the product of the gas pressure and the gap length between the electrodes. The breakdown voltage decreases as the pd increases when pd is small and increases as pd increases when pd becomes large.

GDTs are subjected to both axially parallel and perpendicular magnetic fields. These magnetic fields result in different shifts on the tube's Paschen curve depending on the configuration.

Experiment:

As shown below, the gas discharge tube is connected to a high-voltage DC source. The anode is on the left of the tube and the cathode is on the right. Various structures are seen in the glowing column depending on the gas pressure, the tube length and the operating current.

Citations:

- Petraconi, G., et al., "Longitudinal Magnetic Field Effect on the Electrical Breakdown in Low Pressure Gases" , Brazilian Journal of Physics, vol. 34, no. 4b, Sociedade Brasileira de Física, Dec. 2004, pp. 1662–66, doi:10.1590/S0103-97332004000800028.
- Knight, David W. "Gas Discharge Tube Introduction." G3YNH Info, g3ynh.info/disch_tube/intro.html. Accessed 2 Aug. 2023.

SUSTAINABILITY

PRODUCT ANALYSIS AND CHARACTERIZATION IN ACRYLONITRILE PLASMA REACTIONS

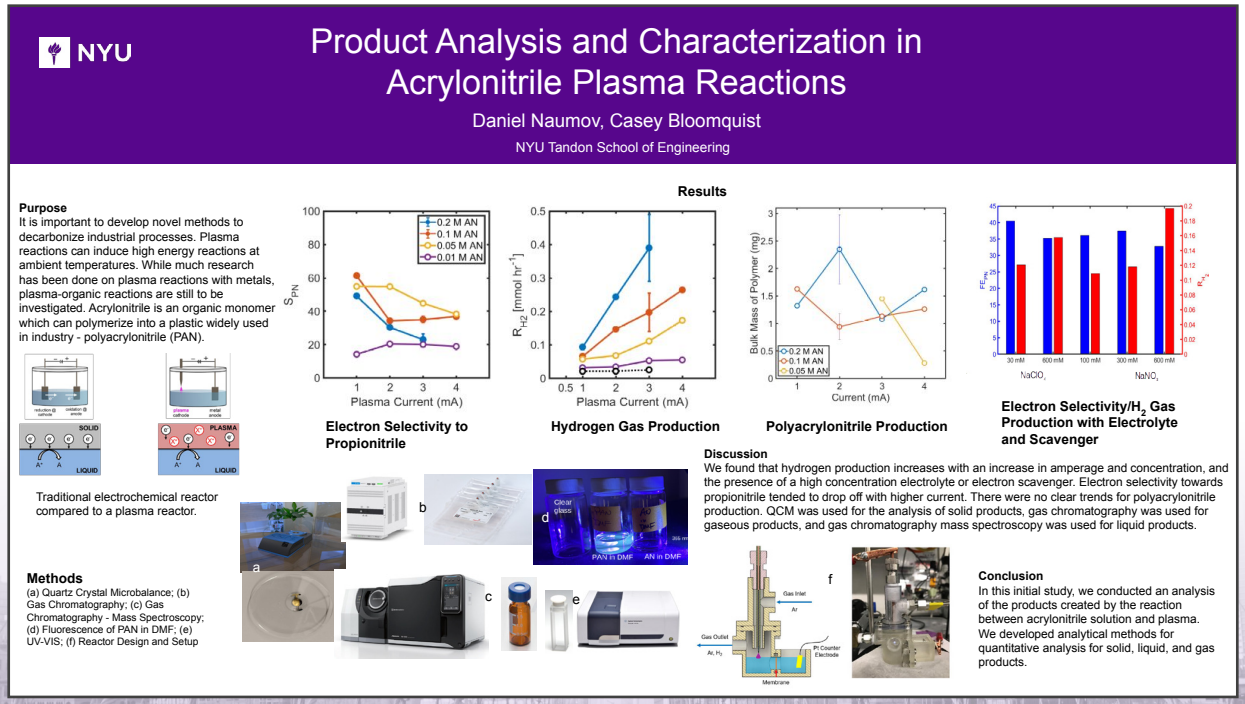
Decreasing reliance on fossil fuels is a critical part of the effort to counteract global warming. However, the chemical manufacturing sector does not have a straightforward path towards fossil fuel independence since many industrial chemical reactions occur at high temperatures, which are only economically accessible through fossil fuel combustion. Electrochemistry offers promising prospects by substituting thermally driven chemical processes with electrically driven ones, which allows renewable energy from the grid to be integrated into chemical production. Plasma reactions make high energy reaction pathways available at ambient temperatures. There is a need to characterize products of various electrochemical reactions to find viable industrial applications, as well as to determine where an electrochemical reaction can induce a thermal one. The scope of this project focuses on acrylonitrile (AN), a monomer used for manufacturing commercially important plastic polymers such as polyacrylonitrile (PAN). In a benchtop reactor, argon plasma reacts with a mixture of AN and water, resulting in products in liquid, solid, and gaseous phases. This includes PAN, hydrogen gas, and propionitrile, a useful solvent and drug building block. Plasma current and current density, presence of an electrolyte or electron scavenger, argon gas flow rate, and AN concentration all play an important role in final product composition.

Project Supervisor: Miguel Modestino (CBE); **Research Staff:** Casey Bloomquist; Ricardo Mathison

Research Area: *Sustainability*



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SUSTAINABILITY

UNDERSTANDING THE ELECTROCHEMICAL SYNTHESIS OF ADIPONITRILE AND ACRYLONITRILE FROM BIOMASS FEEDSTOCKS

Chemical manufacturing predominantly relies on fossil fuels for starting materials and energy, driving the need for sustainable alternatives. Biomass emerges as a viable solution, where renewable electricity can transform its materials. This research aims to develop sustainable polymers, specifically using non-food biomass products like glutamic acid.

Nylon 6,6, widely used in textiles and plastics, depends on the precursor molecule, adiponitrile (ADN), often produced through energy-intensive thermochemical hydrocyanation of 1,3 butadiene, using highly toxic hydrogen cyanide. Alternatively, ADN can be electrochemically produced via acrylonitrile (AN) hydrodimerization, the most prominent organic electrochemical process.

Currently, ADN production heavily relies on fossil fuels. This study explores producing ADN from renewable glutamic acid through the electrolysis of 3-cyanopropanoic acid (CPA) to ADN. Important factors such as electrode material, current density, and substrate concentration have been investigated through over 250 experiments, determining optimal reaction conditions for CPA to ADN. Experiments for CPA to AN were also conducted.

To achieve a comprehensive understanding, a small reactor capable of collecting gas from the reaction was used, ensuring all products are accounted for. This electrochemical process offers the potential to integrate renewable energy sources into chemical manufacturing, presenting an eco-friendly path forward.

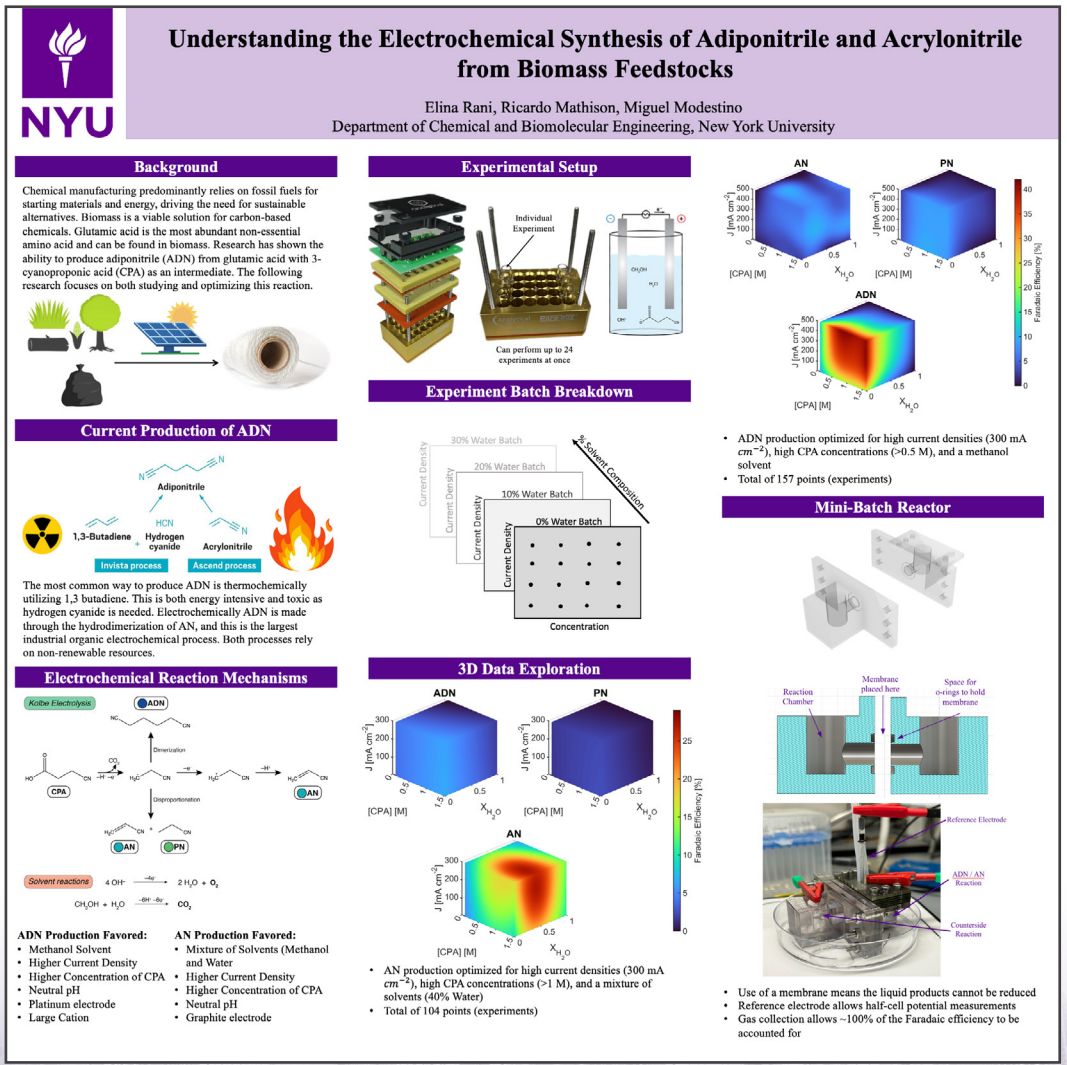
Project Supervisor: Miguel Modestino (CBE); **Research Staff:** Ricardo Mathison

Research Area: *Sustainability*



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GLASS Fellow



SUSTAINABILITY

QUANTIFYING MEMBRANE TRANSPORT PROPERTIES

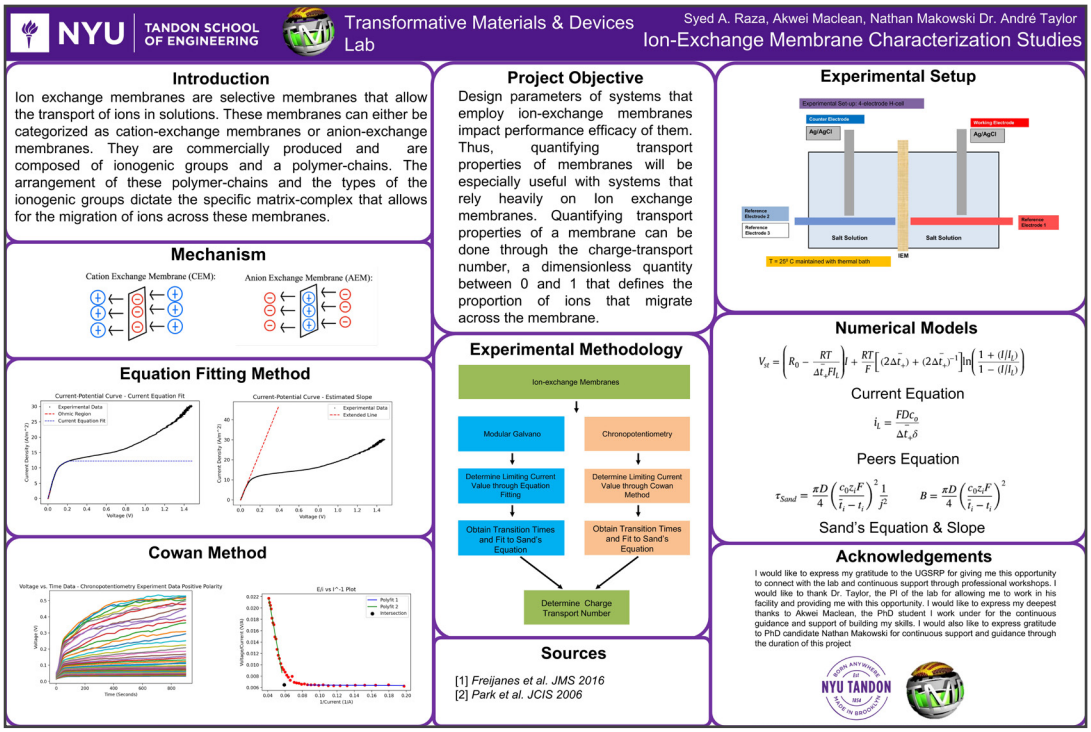
Ion-exchange membranes (IEMs) are widely employed in many commercial processes including fuel cell technology, chemical separation cells, desalination, and so forth, due to their ability to selectively transport ions. As such, an IEM's selectivity is crucial for evaluating its performance in different applications. An IEM's selectivity can be quantified using a value known as the charge-transport number – a value between 0 and 1, where 1 refers to a highly selective IEM. However, the selectivity of IEMs can decrease due to numerous factors, which reduces an IEM's performance for various applications. Thus, identifying the charge-transport number is highly relevant for projecting an IEM's performance. The focus of this research at the New York University Transformative Materials and Devices Lab is to utilize electrochemical methods such as modular galvano and chronopotentiometry to collect current-voltage data allowing for the characterization of the charge-transport number for a membrane. Unraveling the influence of system design in electrochemical cells on this number enhances overall efficiency. Furthermore, this insight guides refining membrane performance, process efficiency, and optimizing membrane-based operations.

Project Supervisor André D. Taylor (CBE); **Research Staff:** Ph.D. Candidate Akwei Maclean

Research Area: *Sustainability*



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SUSTAINABILITY

SUSTAINABLE MEDICINE: IMPLEMENTING CHANGES IN US HEALTHCARE

Sustainability has become a pressing concern within the US healthcare system, prompting the need for innovative strategies to mitigate its environmental impact. This research project explores two distinct yet interconnected methods to achieve it: minimizing waste in the Operating Room (OR), using cataract surgeries as a model, and limiting disruptions in Personal Protective Equipment (PPE) orders while bolstering supply chain resilience, a lesson learned during the COVID-19 pandemic.

Cataract surgery is a common procedure which generates substantial waste, including single-use equipment and packaging materials. An analysis of waste audit reports from NYU Langone Health provides insight into the current disposal practices. Interviews with healthcare practitioners also provide valuable insights into waste reduction, recycling, and the integration of sustainable practices.

The study also delves into PPE order disruptions experienced during the COVID-19 pandemic to reveal vulnerabilities in the healthcare supply chain. A thorough analysis of quantitative data, such as sudden increases in orders, helps to enhance the resilience strategies employed by healthcare organizations. The audits reveal significant opportunities for waste reduction in cataract surgeries, highlighting the adoption of reusable medical instruments and recyclable materials as a way to substantially decrease the environmental impact.

The analysis of the COVID-19 supply chain disruptions exposes critical weaknesses in the healthcare system's ability to respond to emergencies and shows opportunities for implementing resilience strategies and preventing future shortages.

By auditing waste during cataract surgeries and mitigating PPE order disruptions, this research project offers a holistic framework for achieving sustainable medicine. Healthcare institutions and policymakers can use these findings to implement eco-friendly measures and enhance supply chains, for a greener and more resilient future.

Project Supervisor: Cassandra Thiel (CUE)
Research Areas: *Sustainability, Health*



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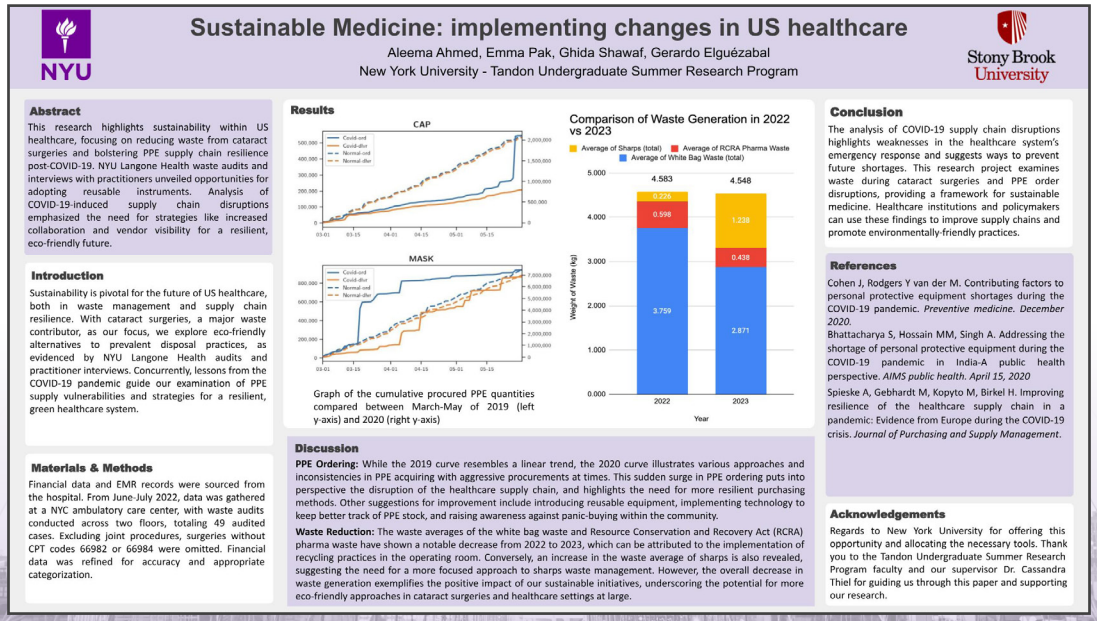


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Sustainable Medicine: implementing changes in US healthcare

Aleema Ahmed, Emma Pak, Ghida Shawaf, Gerardo Elguézabal
New York University - Tandon Undergraduate Summer Research Program

NYU

Stony Brook University

Abstract

This research highlights sustainability within US healthcare, focusing on reducing waste from cataract surgeries and bolstering PPE supply chain resilience post-COVID-19. NYU Langone Health waste audits and interviews with practitioners unveiled opportunities for adopting reusable instruments. Analysis of COVID-19-induced supply chain disruptions emphasized the need for strategies like increased collaboration and vendor visibility for a resilient, eco-friendly future.

Introduction

Sustainability is pivotal for the future of US healthcare, both in waste management and supply chain resilience. With cataract surgeries, a major waste contributor, as our focus, we explore eco-friendly alternatives to prevalent disposal practices, as evidenced by NYU Langone Health audits and practitioner interviews. Concurrently, lessons from the COVID-19 pandemic guide our examination of PPE supply vulnerabilities and strategies for a resilient, green healthcare system.

Materials & Methods

Financial data and EMR records were sourced from the hospital. From June-July 2022, data was gathered at a NYC ambulatory care center, with waste audits conducted across two floors, totaling 49 audited cases. Excluding joint procedures, surgeries without CPT codes 66982 or 66984 were omitted. Financial data was refined for accuracy and appropriate categorization.

Results

CAP

MASK

Graph of the cumulative procured PPE quantities compared between March-May of 2019 (left y-axis) and 2020 (right y-axis)

Comparison of Waste Generation in 2022 vs 2023

Average of Sharps (total) · Average of RCRA Pharma Waste · Average of White Bag Waste (total)

Weight of Waste (kg)

Year

Discussion

PPE Ordering: While the 2019 curve resembles a linear trend, the 2020 curve illustrates various approaches and inconsistencies in PPE acquiring with aggressive procurements at times. This sudden surge in PPE ordering puts into perspective the disruption of the healthcare supply chain, and highlights the need for more resilient purchasing methods. Other suggestions for improvement include introducing reusable equipment, implementing technology to keep better track of PPE stock, and raising awareness against panic-buying within the community.

Waste Reduction: The waste averages of the white bag waste and Resource Conservation and Recovery Act (RCRA) pharma waste have shown a notable decrease from 2022 to 2023, which can be attributed to the implementation of recycling practices in the operating room. Conversely, an increase in the waste average of sharps is also revealed, suggesting the need for a more focused approach to sharps waste management. However, the overall decrease in waste generation exemplifies the positive impact of our sustainable initiatives, underscoring the potential for more eco-friendly approaches in cataract surgeries and healthcare settings at large.

Conclusion

The analysis of COVID-19 supply chain disruptions highlights weaknesses in the healthcare system's emergency response and suggests ways to prevent future shortages. This research project examines waste during cataract surgeries and PPE order disruptions, providing a framework for sustainable medicine. Healthcare institutions and policymakers can use these findings to improve supply chains and promote environmentally-friendly practices.

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Acknowledgements

Regards to New York University for offering this opportunity and allocating the necessary tools. Thank you to the Tandon Undergraduate Summer Research Program faculty and our supervisor Dr. Cassandra Thiel for guiding us through this paper and supporting our research.

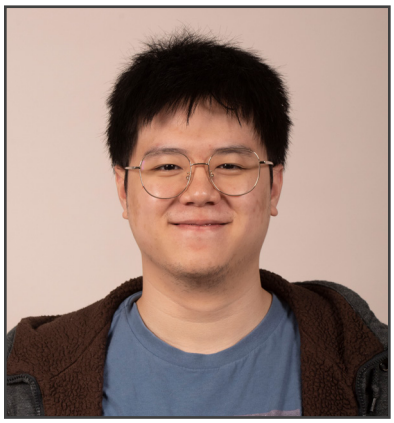
SUSTAINABILITY

UTILIZING MICROFLUIDICS AND DEAN FLOW-FOCUSING FOR EFFICIENT SPECTROSCOPIC ANALYSIS OF MICROPLASTICS

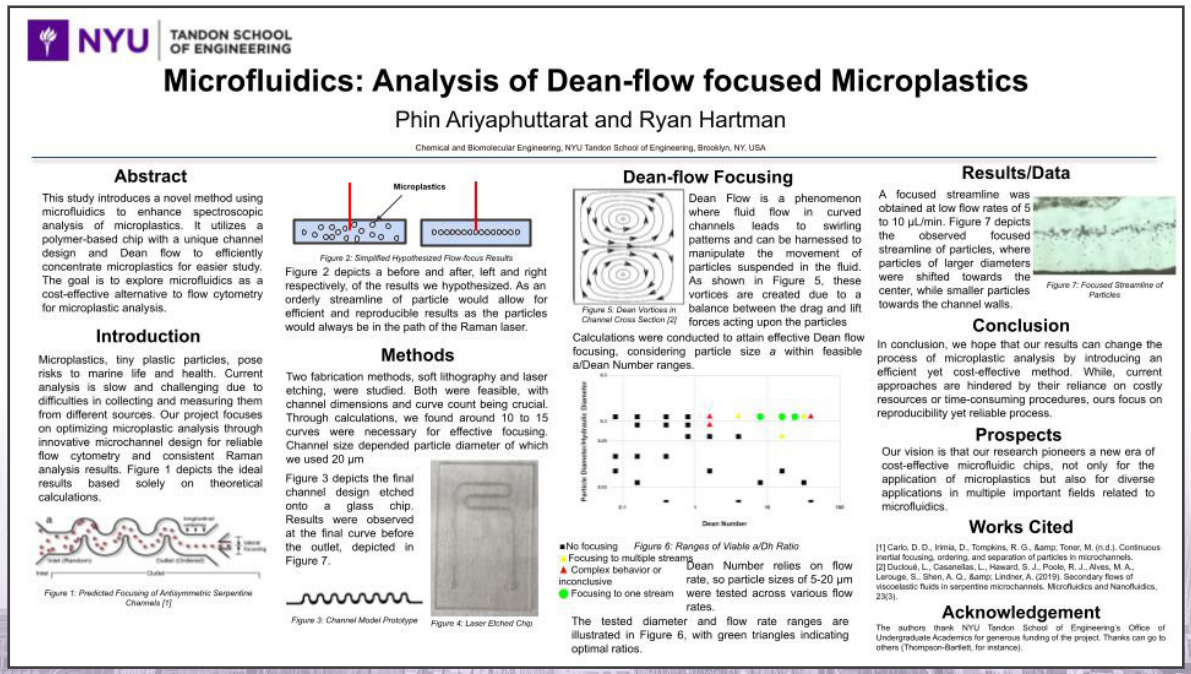
Microplastics, minute plastic particles ranging from 5 millimeters to a few micrometers in size, have raised concerns among biologists and physiologists regarding their potential hazardous impact on marine life and human health. Traditional methods for microplastic analysis are time-consuming, relying on trial-and-error and probability. One of the difficulties in microplastics research involves collecting these minuscule particles from various sources, including water, sediment, and organisms. Scientists have explored various sampling techniques, yet the small size of microplastics and the extensive range of samples make their identification and measurement quite challenging.This study introduces an innovative approach employing microfluidics, a technique manipulating fluids within micrometer-scale channels, to facilitate spectroscopic analysis of microplastics. An antisymmetric serpentine channel design on a polymer-based microfluidic chip, utilizing Dean flow, is implemented to efficiently redistribute microplastics within the sample. Dean flow is a method that uses the flow patterns in curved channels to gather microplastic particles together in one or separate streams. This helps concentrate the microplastics effectively, making it easier to study them using spectroscopy. The use of a polymer-based chip ensures reproducibility and an effective microplastic focusing system. Through spectroscopic analysis of the vibrational and chemical frequencies of microplastics, this study aims to shed light on how application of microfluidics can provide a cheap alternative to flow cytometry.

Project Supervisor: Ryan Hartman (CBE); **Research Staff:** Charan Kukunoor

Research Areas: *Sustainability, Health*



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NYU TANDON SCHOOL OF ENGINEERING

Microfluidics: Analysis of Dean-flow focused Microplastics

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Abstract

This study introduces a novel method using microfluidics to enhance spectroscopic analysis of microplastics. It utilizes a polymer-based chip with a unique channel design and Dean flow to efficiently concentrate microplastics for easier study. The goal is to explore microfluidics as a cost-effective alternative to flow cytometry for microplastic analysis.

Introduction

Microplastics, tiny plastic particles, pose risks to marine life and health. Current analysis is slow and challenging due to difficulties in collecting and measuring them from different sources. Our project focuses on optimizing microplastic analysis through innovative microchannel design for reliable flow cytometry and consistent Raman analysis results. Figure 1 depicts the ideal results based solely on theoretical calculations.

Figure 1: Predicted Focusing of Antisymmetric Serpentine Channels [1]

Figure 2: Simplified Hypothesized Flow-focus Results

Figure 2 depicts a before and after, left and right respectively, of the results we hypothesized. As an orderly streamline of particle would allow for efficient and reproducible results as the particles would always be in the path of the Raman laser.

Methods

Two fabrication methods, soft lithography and laser etching, were studied. Both were feasible, with channel dimensions and curve count being crucial. Through calculations, we found around 10 to 15 curves were necessary for effective focusing. Channel size depended particle diameter of which we used 20 μm

Figure 3 depicts the final channel design etched onto a glass chip. Results were observed at the final curve before the outlet, depicted in Figure 7.

Figure 3: Channel Model Prototype

Figure 4: Laser Etched Chip

Dean-flow Focusing

Figure 5: Dean Vortices in Channel Cross Section [2]

Dean Flow is a phenomenon where fluid flow in curved channels leads to swirling patterns and can be harnessed to manipulate the movement of particles suspended in the fluid. As shown in Figure 5, these vortices are created due to a balance between the drag and lift forces acting upon the particles

Calculations were conducted to attain effective Dean flow focusing, considering particle size *a* within feasible a/Dean Number ranges.

Figure 6: Ranges of Viable a/Dh Ratio

■No focusing
▲Focusing to multiple streams
▲Complex behavior or inconclusive
●Focusing to one stream

Dean Number relies on flow rate, so particle sizes of 5-20 μm were tested across various flow rates.

The tested diameter and flow rate ranges are illustrated in Figure 6, with green triangles indicating optimal ratios.

Results/Data

A focused streamline was obtained at low flow rates of 5 to 10 μL/min. Figure 7 depicts the observed focused streamline of particles, where particles of larger diameters were shifted towards the center, while smaller particles towards the channel walls.

Figure 7: Focused Streamline of Particles

Conclusion

In conclusion, we hope that our results can change the process of microplastic analysis by introducing an efficient yet cost-effective method. While, current approaches are hindered by their reliance on costly resources or time-consuming procedures, ours focus on reproducibility yet reliable process.

Prospects

Our vision is that our research pioneers a new era of cost-effective microfluidic chips, not only for the application of microplastics but also for diverse applications in multiple important fields related to microfluidics.

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[2] Ducloué, L., Casanellas, L., Haward, S. J., Poole, R. J., Alves, M. A., Lerouge, S., Shen, A. Q., & Lindner, A. (2019). Secondary flows of viscoelastic fluids in serpentine microchannels. Microfluidics and Nanofluidics, 23(3).

Acknowledgement

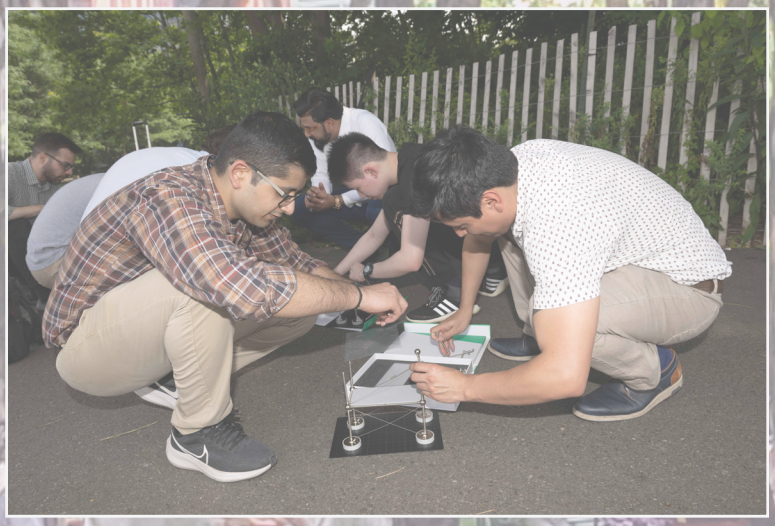
The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for generous funding of the project. Thanks can go to others (Thompson-Bartlett, for instance).

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.

FACULTY

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LEARN MORE

A COMPUTER VISION-BASED APPROACH TO ENHANCE URBAN BUILDING FAÇADE INSPECTIONS IN CITIES

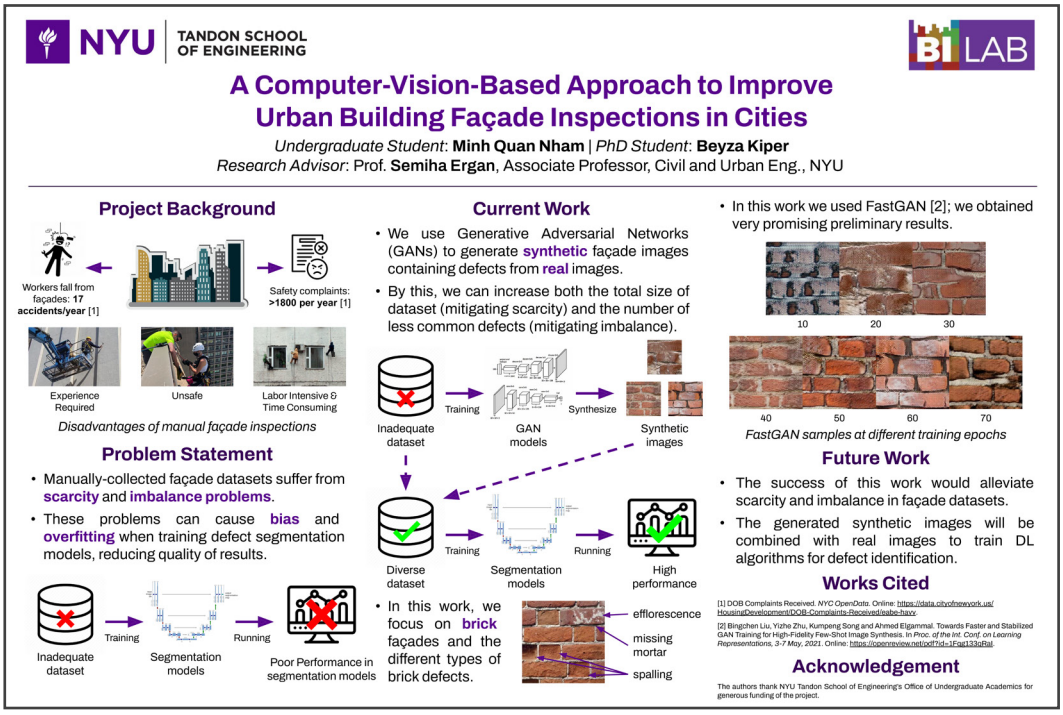
Assessing the state of urban building façades is vital for building maintenance and public safety. Current inspection methods are labor-intensive and unsafe since they are mostly carried out manually and visually. Recent developments in the area have focused on automating defect detection, and deep learning (DL) methods using image classification and segmentation models have gained success in correctly identifying defects. Earlier research has effectively utilized a range of DL models to enhance the accuracy of façade defect detection. However, these approaches were found to be somewhat limited, primarily due to issues related to small or unbalanced datasets. To counter this, our method emphasizes data augmentation using Generative Adversarial Networks (GANs), which are a type of DL model adept at producing realistic synthetic images that closely resemble the original ones. By generating synthetic images of façade defects, we aim to address the issue of limited data, thereby enhancing the precision of automated checks. These synthetic images serve to enrich the existing dataset, ensuring defects are represented more comprehensively while also addressing the issues of limited and imbalanced data. We also incorporate data preprocessing and labeling techniques to further enhance the organization and accuracy of the dataset, considerably improving the automated defect detection models. Our findings underscore the transformative power of computer vision and DL in updating urban building façade inspections, ultimately promoting greater public safety.

Project Supervisor/Faculty Mentor: Semiha Ergan (CUE); **Research Staff:** Beyza Kiper

Research Areas: *Urban, Data Science/AI/Robotics*



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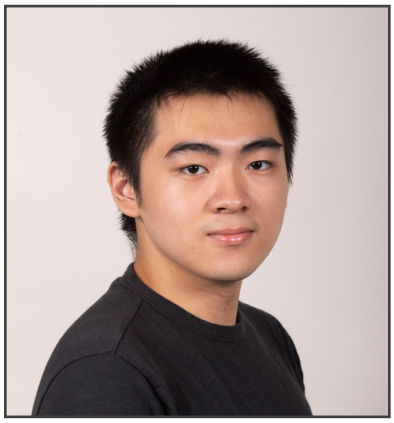


ASSESSING THE RISK OF NEW YORK CITY TO FLOODS

New York City (NYC) faces the vulnerability of pluvial flooding during torrential rain events, such as Hurricane Ida and Hurricane Henry, due to its limited infiltration capacity. To tackle this problem, the City relies on two sources of information: the Stormwater Flood Maps, which are based on hydrological and hydraulic (H&H) models, and 311 data. However, the flood maps have uncertainties related to the model, while 311 reporting has biases raising equity concerns. In this study, our objective was to identify discrepancies between the two sources of information through a regression analysis, which may reveal mispredictions of the flood model and equity concerns in the use of the 311 reporting system. Site visits were conducted to investigate these discrepancies. We explored areas with high 311 calls but no predicted flooding, and we found imprecision in the flood model. On the other hand, we also visited areas with high flood expectations according to the model, but no 311 calls were made, and we uncovered an equity issue where conditions like language proficiencies prevented reporting. These findings highlight the potential of the 311 service as an adjunct to the City's flood risk prevention measures by comparison to the flood maps. Additionally, they emphasize issues of equity among specific communities. Further research is recommended to address the biases in 311 data, enabling the development of more inclusive and effective flood prevention measures.

Project Supervisor: Luis Ceferino (CUE, CUSP); **Research Staff:** Riccardo Negri

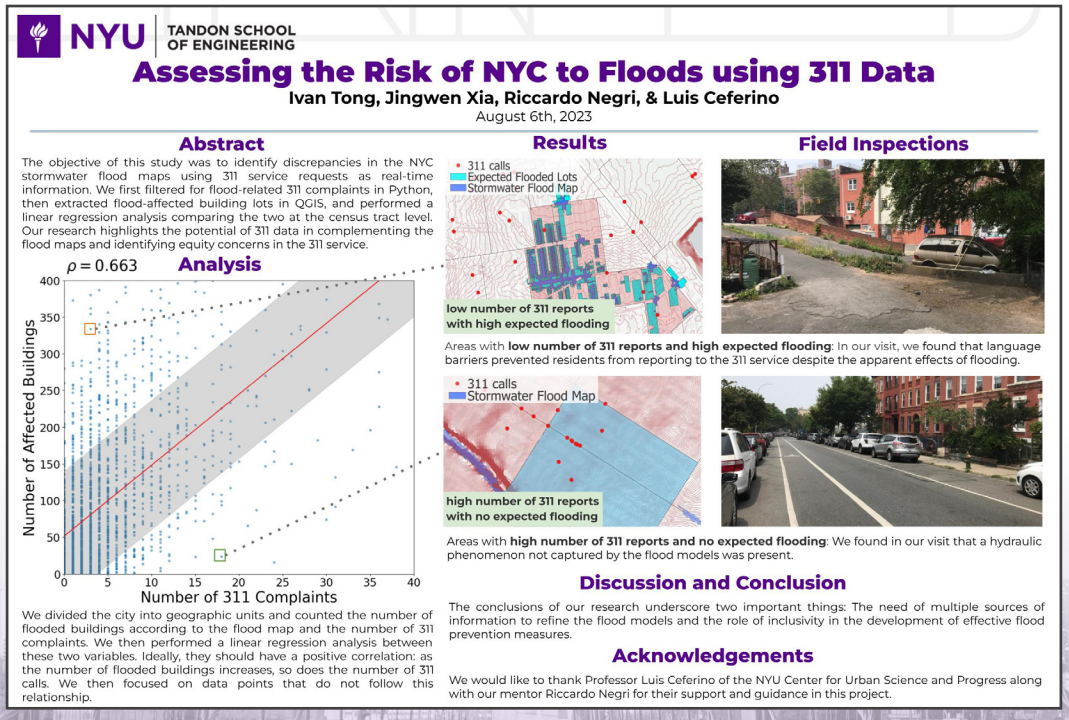
Research Areas: *Urban, Sustainability*



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BUILDING RESILIENCE THROUGH COMMUNITY SCIENCE AND DESIGN FOR ADVOCACY

New York's Chinatown harbors a rich cultural heritage, but its significance is overshadowed by the escalating air and noise pollution levels reaching record highs as a result of various environmental crises, such as the 2023 Canadian wildfire smoke that caused the city's air quality to rank the worst in the world as well as the construction of NYC's first of a series of 4 mega jails, set to be the tallest detention center in the world. The construction project will pose lasting environmental and health risks to the already vulnerable population. Presently, local residents have little access to environmental data measuring the construction's effect on noise and air quality. Our research team endeavors to improve access to health information and promote awareness around the harmful effects of air and noise pollution on individual health. By utilizing real-time purple-air quality sensors and additional self-monitoring tools to quantify the impact of the construction on noise and air, our project aims to create access to public health data. In collaboration with the local high school students, NYU Center for the Study of Asian American Health (CSAAH) based in NYU Langone, and the Immigrant Social Services (ISS), a community non-profit organization based in Chinatown, we will design workshops and protocols at The SHOP (Storefront for Ideas). During the workshops, participants will learn how to use the noise & air quality sensors to collect and interpret data in a comprehensible manner and make 311 calls when necessary to express concerns. We hope non-professionals will be equipped to train citizens, thereby creating a positive feedback loop of knowledge dissemination. Ultimately, this approach will empower the community to proactively address the environmental and health risks posed by the construction activities.

Project Supervisor: Graham Dove (TMI, CUSP)

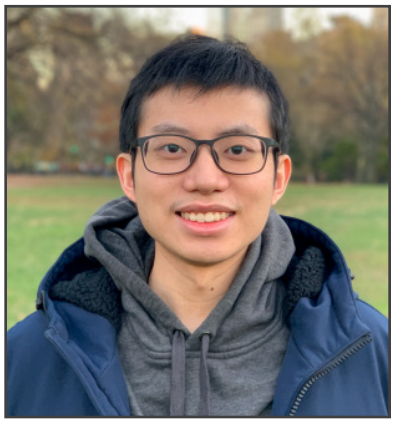
Research Areas: *Urban, Health, Sustainability*



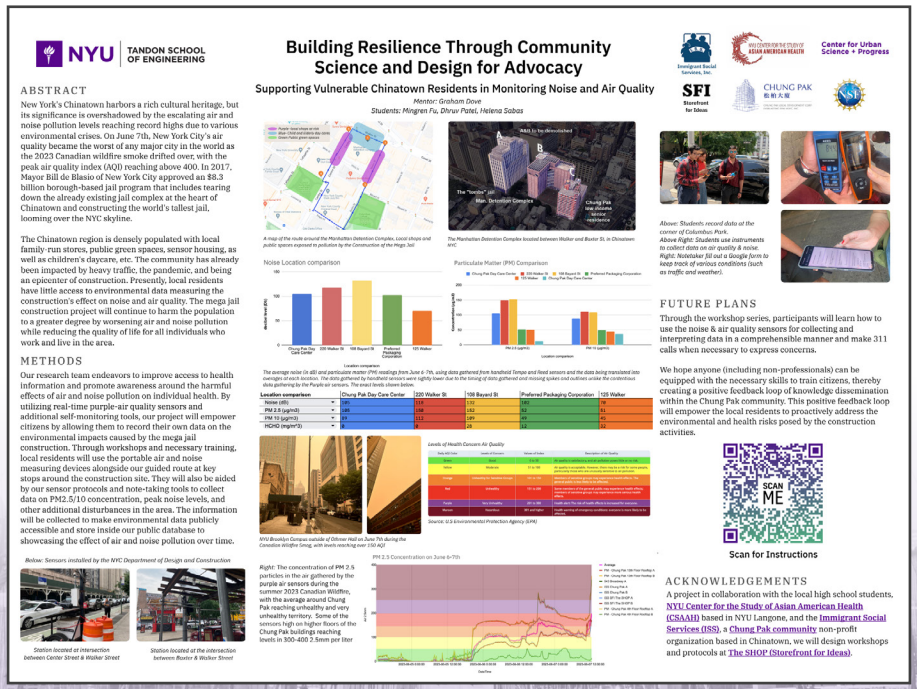
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NYU TANDON SCHOOL OF ENGINEERING

Building Resilience Through Community Science and Design for Advocacy

Supporting Vulnerable Chinatown Residents in Monitoring Noise and Air Quality

Mentor: Graham Dove

Students: Mingren Fu, Dhruv Patel, Helena Sabas

Center for Urban Science + Progress

ABSTRACT

New York's Chinatown harbors a rich cultural heritage, but its significance is overshadowed by the escalating air and noise pollution levels reaching record highs due to various environmental crises. On June 7th, New York City's air quality became the worst of any major city in the world as the 2023 Canadian wildfire smoke drifted over, with the peak air quality index (AQI) reaching above 400. In 2017, Mayor Bill de Blasio of New York City approved an $8.3 billion borough-based jail program that includes tearing down the already existing jail complex at the heart of Chinatown and constructing the world's tallest jail, looming over the NYC skyline.

The Chinatown region is densely populated with local family-run stores, public green spaces, senior housing, as well as children's daycare, etc. The community has already been impacted by heavy traffic, the pandemic, and being an epicenter of construction. Presently, local residents have little access to environmental data measuring the construction's effect on noise and air quality. The mega jail construction project will continue to harm the population to a greater degree by worsening air and noise pollution while reducing the quality of life for all individuals who work and live in the area.

METHODS

Our research team endeavors to improve access to health information and promote awareness around the harmful effects of air and noise pollution on individual health. By utilizing real-time purple-air quality sensors and additional self-monitoring tools, our project will empower citizens by allowing them to record their own data on the environmental impacts caused by the mega jail construction. Through workshops and necessary training, local residents will use the portable air and noise measuring devices alongside our guided route at key stops around the construction site. They will also be aided by our sensor protocols and note-taking tools to collect data on PM2.5/10 concentration, peak noise levels, and other additional disturbances in the area. The information will be collected to make environmental data publicly accessible and store inside our public database to showcasing the effect of air and noise pollution over time.

Below: Sensors installed by the NYC Department of Design and Construction

Station located at intersection between Center Street & Walker Street

Station located at the intersection between Baxter & Walker Street

A map of the route around the Manhattan Detention Complex. Local shops and public spaces exposed to pollution by the Construction of the Mega Jail.

The Manhattan Detention Complex located between Walker and Baxter St. in Chinatown NYC

Noise Location comparison

Particulate Matter (PM) Comparison

The average noise (in dB) and particulate matter (PM) readings from June 6- 7th, using data gathered from handheld Tenpo and Reed sensors and the data being translated into averages of each location. The data gathered by handheld sensors were lightly lower due to the timing of data gathered and missing spikes and outliers unlike the contentious data gathered by the People air sensors. The exact levels shown below.

Location comparison	Chung Pak Day Care Center	220 Walker St	108 Bayard St	Preferred Packaging Corporation	125 Walker
Noise (dB)	96	124	122	116	122
PM 2.5 (µg/m3)	180	158	152	92	91
PM 10 (µg/m3)	92	113	149	85	85
HCHO (mg/m^3)	0	1	25	12	22

Levels of Health Concern Air Quality

Source: U.S Environmental Protection Agency (EPA)

NYU Brooklyn Campus outside of Othmer Hall on June 7th during the Canadian Wildfire Smog, with levels reaching over 150 AQI

Right: The concentration of PM 2.5 particles in the air gathered by the purple air sensors during the summer 2023 Canadian Wildfire, with the average around Chung Pak reaching unhealthy and very unhealthy territory. Some of the sensors high on higher floors of the Chung Pak buildings reaching levels in 300-400 2.5mm per liter

PM 2.5 Concentration on June 6-7th

Above: Students record data at the corner of Columbus Park.
Above Right: Students use instruments to collect data on air quality & noise.
Right: Notetaker fill out a Google form to keep track of various conditions (such as traffic and weather).

FUTURE PLANS

Through the workshop series, participants will learn how to use the noise & air quality sensors for collecting and interpreting data in a comprehensible manner and make 311 calls when necessary to express concerns.

We hope anyone (including non-professionals) can be equipped with the necessary skills to train citizens, thereby creating a positive feedback loop of knowledge dissemination within the Chung Pak community. This positive feedback loop will empower the local residents to proactively address the environmental and health risks posed by the construction activities.

SCAN ME

Scan for Instructions

ACKNOWLEDGEMENTS

A project in collaboration with the local high school students, NYU Center for the Study of Asian American Health (CSAAH) based in NYU Langone, and the Immigrant Social Services (ISS), a Chung Pak community non-profit organization based in Chinatown, we will design workshops and protocols at The SHOP (Storefront for Ideas).

DEVELOPING DIVERSITY & EQUITY TRAINING FOR UNDERGRADUATE ENGINEERING TEACHING ASSISTANTS

Undergraduate TAs play a key role in student success in the first-year engineering experience at NYU Tandon. Effective TAs are leaders and peer mentors; they assist with content delivery, assessment, and completion of hands-on labs and projects. As initial points-of-contact for students, TAs' own understanding of how to foster inclusivity is essential for creating an equitable classroom environment. In conjunction with the TA body and diversity, equity, and inclusion (DEI) experts at our institution, we have thus sought to co-create DEI training for our program. The training introduces TAs to concepts such as inclusive communities, inclusive language, inclusive leadership, and conflict resolution techniques. Over the past three years, we have developed a tiered training system designed to deliver DEI concepts to TAs through workshops comprised of active discussions and case scenarios. We have also conducted regular climate surveys, listening sessions, and self evaluations to measure the effectiveness of this training. Throughout this process, both quantitative and qualitative responses have been analyzed through careful key-word network diagramming. The results of this analysis revealed a need for increased attention to conflict management strategies, a refinement of key objectives and takeaways, and exercises designed to translate DEI concepts into workplace and industry skills. With this feedback, the third and final tier of the training was developed, and previous years' trainings have been further refined. We have also developed a metric for storing and comparing effectiveness data over multiple cohorts of TAs for a continuous longitudinal study, and added a library of accessible resources for TAs and faculty to utilize throughout the course including an inclusive language guide and website. Through this process, we seek to establish a set of DEI learning objectives for undergraduate TAs that evolve and adapt to a continuously changing social and work climate that remain applicable beyond our institution.

Project Supervisor: Ingrid Paredes (GE)

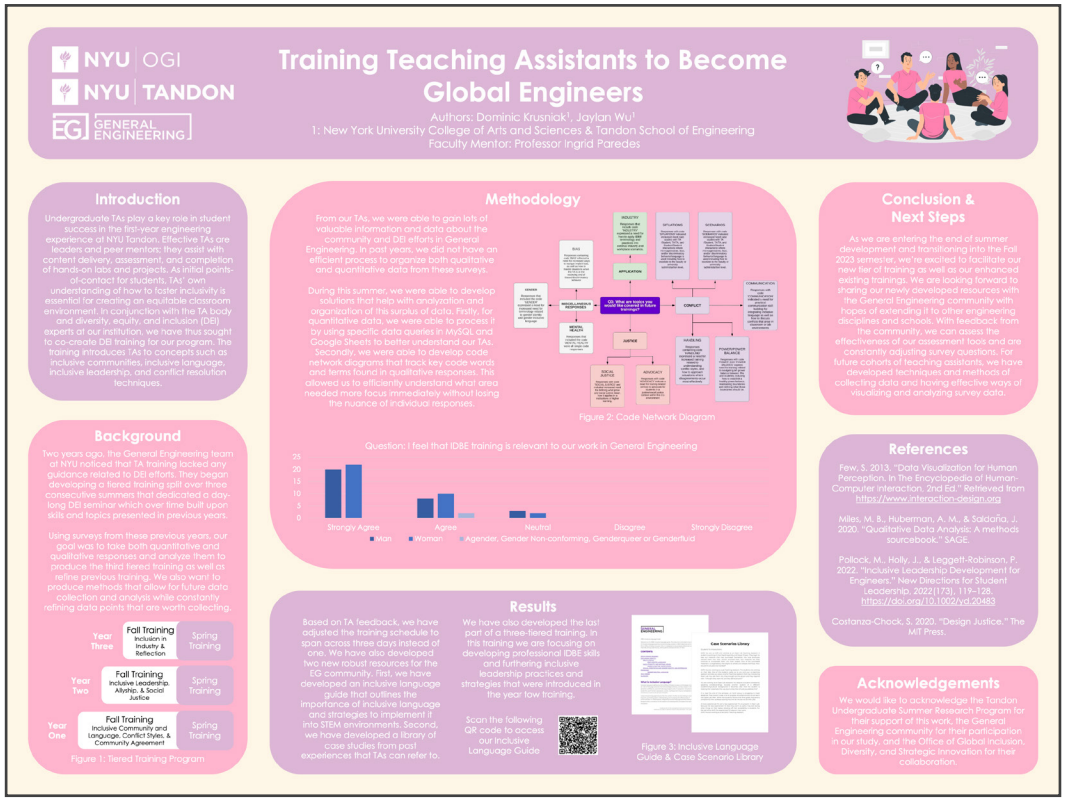
Research Area: *Urban*



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ENHANCING EQUITABLE PEDESTRIAN SAFETY IN SMART CITIES: A DIGITAL TWIN APPROACH WITH ADAPTIVE SIGNAL CONTROL FOR PEDESTRIANS WITH MOBILITY AIDS

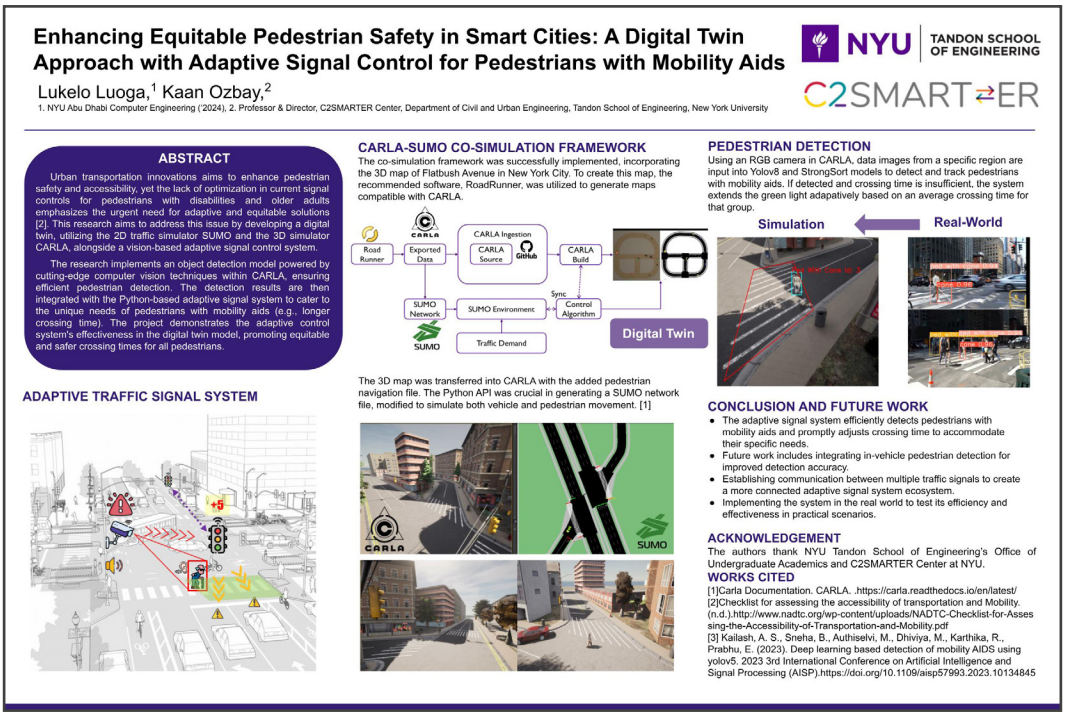
Enhancing pedestrian safety and accessibility in smart cities is a crucial goal for modern transportation innovations. However, current pedestrian signal controls often lack optimization for individuals with disabilities and older adults, highlighting the urgent need for adaptive and equitable solutions. This research aims to address this issue by developing a digital twin, utilizing the 2D traffic simulator SUMO and the 3D simulator CARLA, alongside a vision-based adaptive signal control system. The primary focus is on enhancing pedestrian safety, particularly for those utilizing mobility aids. To achieve this, the research project aims to build a beta version of a digital twin, enabling real-time vehicle and pedestrian input exchange between SUMO and the CARLA simulator. This integration facilitates dynamic and precise simulations of real-world traffic scenarios involving both vehicles and pedestrians. Additionally, the research implements an object detection model powered by cutting-edge computer vision techniques within CARLA, ensuring efficient pedestrian detection, with a specific emphasis on individuals using mobility aids. The insights from the detection model play a crucial role in shaping the Python-based adaptive signal system to cater to the unique needs of pedestrians with mobility aids. The project demonstrates the effectiveness of the adaptive control system in the digital twin model, promoting equitable crossing times for pedestrians with mobility aids, and ultimately enhancing safety and accessibility for marginalized communities.

Project Supervisor: Kaan Ozbay (CUE, CUSP); **Research Staff:** Fan Zuo, Jingqin Gao

Research Areas: *Urban, Data Science/AI/Robotics*



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Enhancing Equitable Pedestrian Safety in Smart Cities: A Digital Twin Approach with Adaptive Signal Control for Pedestrians with Mobility Aids

Lukelo Luoga,[1] Kaan Ozbay,[2]

1. NYU Abu Dhabi Computer Engineering ('2024), 2. Professor & Director, C2SMARTER Center, Department of Civil and Urban Engineering, Tandon School of Engineering, New York University

NYU TANDON SCHOOL OF ENGINEERING

C2SMART ER

ABSTRACT

Urban transportation innovations aims to enhance pedestrian safety and accessibility, yet the lack of optimization in current signal controls for pedestrians with disabilities and older adults emphasizes the urgent need for adaptive and equitable solutions [2]. This research aims to address this issue by developing a digital twin, utilizing the 2D traffic simulator SUMO and the 3D simulator CARLA, alongside a vision-based adaptive signal control system.

The research implements an object detection model powered by cutting-edge computer vision techniques within CARLA, ensuring efficient pedestrian detection. The detection results are then integrated with the Python-based adaptive signal system to cater to the unique needs of pedestrians with mobility aids (e.g., longer crossing time). The project demonstrates the adaptive control system's effectiveness in the digital twin model, promoting equitable and safer crossing times for all pedestrians.

CARLA-SUMO CO-SIMULATION FRAMEWORK

The co-simulation framework was successfully implemented, incorporating the 3D map of Flatbush Avenue in New York City. To create this map, the recommended software, RoadRunner, was utilized to generate maps compatible with CARLA.

PEDESTRIAN DETECTION

Using an RGB camera in CARLA, data images from a specific region are input into Yolov8 and StrongSort models to detect and track pedestrians with mobility aids. If detected and crossing time is insufficient, the system extends the green light adapatively based on an average crossing time for that group.

ADAPTIVE TRAFFIC SIGNAL SYSTEM

The 3D map was transferred into CARLA with the added pedestrian navigation file. The Python API was crucial in generating a SUMO network file, modified to simulate both vehicle and pedestrian movement. [1]

CONCLUSION AND FUTURE WORK

- The adaptive signal system efficiently detects pedestrians with mobility aids and promptly adjusts crossing time to accommodate their specific needs.
- Future work includes integrating in-vehicle pedestrian detection for improved detection accuracy.
- Establishing communication between multiple traffic signals to create a more connected adaptive signal system ecosystem.
- Implementing the system in the real world to test its efficiency and effectiveness in practical scenarios.

ACKNOWLEDGEMENT

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics and C2SMARTER Center at NYU.

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ENHANCING URBAN MOBILITY: REAL-TIME HIGH-CAPACITY RIDE-SHARING ALGORITHM FOR EFFICIENT AND SUSTAINABLE TRANSPORTATION

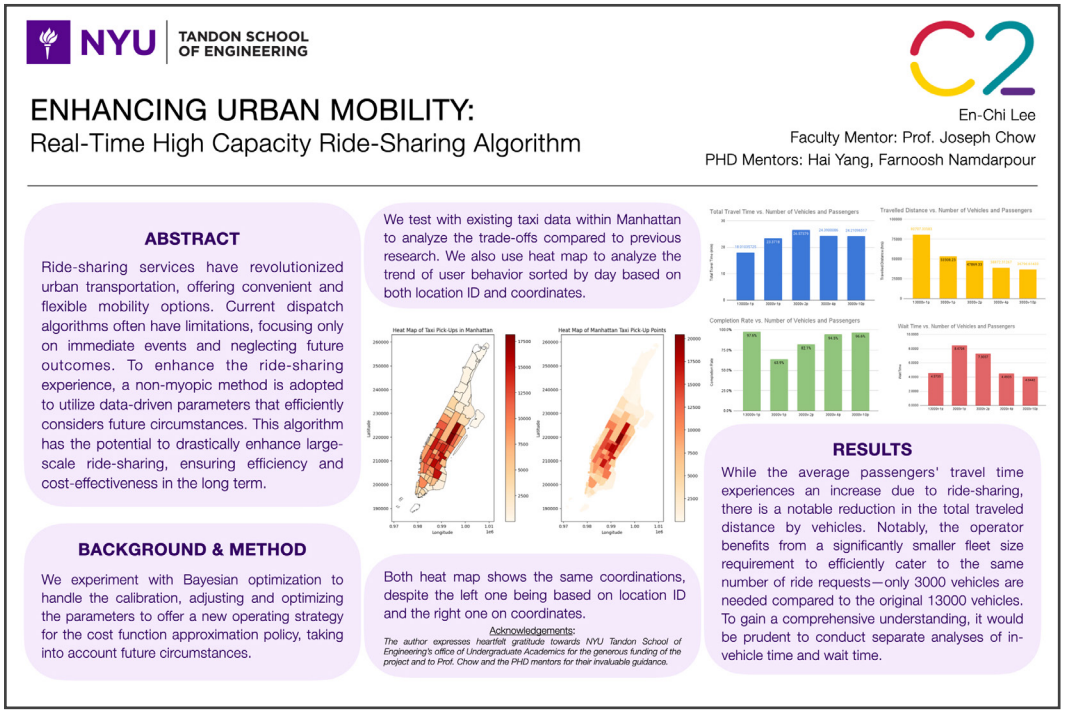
Ride-sharing services have significantly transformed urban transportation in major cities, providing services with comfort and versatile mobility options. To optimize the ride-sharing experience, it becomes crucial to address certain challenges that may prevail and further enhance the overall efficiency of the system. Existing dispatch algorithms for ride-sharing services adopt a myopic approach, one that limits decisions on concurrent events and ignore future outcomes. Non-myopic methods rely on parameters that require calibration from data. Such methods are capable of efficiently handling large numbers of passengers and trips, all while dynamically generating optimal routes based on demand and vehicle locations. We experiment with Bayesian optimization to handle the calibration, adjusting and optimizing the parameters to offer a new operating strategy for the cost function approximation policy, taking into account future circumstances. We test with existing taxi data within Manhattan to analyze the trade-offs compared to the previous research. This algorithm has the potential to drastically enhance large-scale ride-sharing, ensuring both minimized cost and efficient mobility in the long term, which can reduce carbon emissions and provide mobility for everyone in an equitable manner.

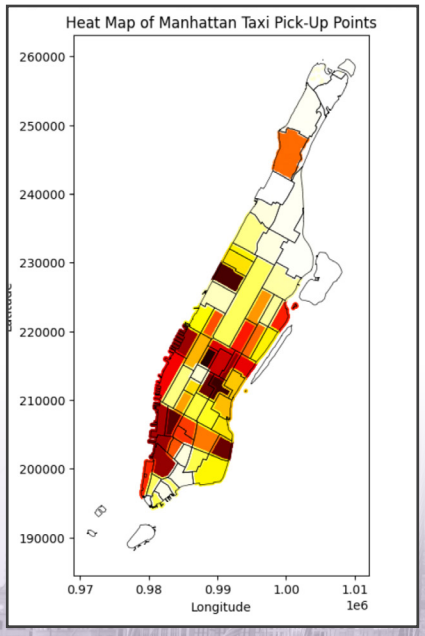
Project Supervisor: Joseph Chow (CUE)

Research Areas: *Urban, Sustainability*



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The heat map showcases Manhattan's taxi pick-up points in a concise and objective manner. It provides valuable insights into the distribution and concentration of pick-up locations, aiding ride-sharing services and urban planning. The color-coded representation enables easy identification of patterns and trends, making it valuable for data analysts and decision-makers.



GRID RESILIENCE TO HURRICANES WITH PRIVATE SOLAR PANELS AND BEHIND-THE-METER BATTERIES USING HURRICANE ISAIAS (2020) AS A CASE STUDY

Hurricanes often cause extensive damage to the power grid, leading to cascading widespread outages. With climate change causing an increase in storm frequency and intensity, it is crucial to improve the resilience of power grids to future storms. This study explores alternative forms of power generation. This study focused on the contributions of solar panels and behind-the-meter batteries in microgrids to power residential homes during Hurricane Isaias (2020) in New Jersey.

We used a dataset of power outages in 13,176 households obtained from Jersey Central Power & Light in Marlboro Township. We analyzed the unserved power demand during Hurricane Isaias (2020). We compared hourly consumption with potential energy production based on available roof space and solar radiation data. During Hurricane Isaias (2020), over 480,000 of total customer interruption hours were recorded, but with the implementation of microgrids, the total outage hours decreased to around 200,000, reducing the duration to 39% of the original value. The impact of strong winds on solar panels and subsequent failure was also modeled using monte-carlo methods.

The economic feasibility of widespread implementation of solar panels and batteries in New Jersey needs consideration in further research. Overall our findings highlight the potential of solar panel installations to enhance the resilience of power grids during hurricanes.

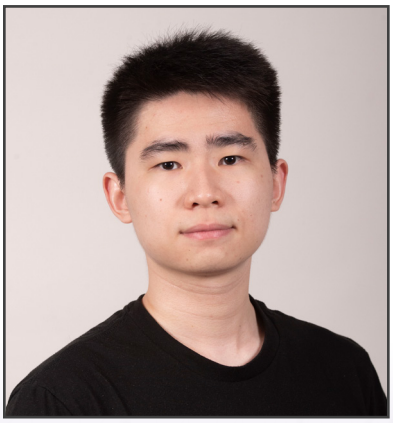
Project Supervisor: Luis Ceferino (CUE, CUSP); **Research Staff:** Prateek Arora

Research Areas: *Urban, Sustainability*

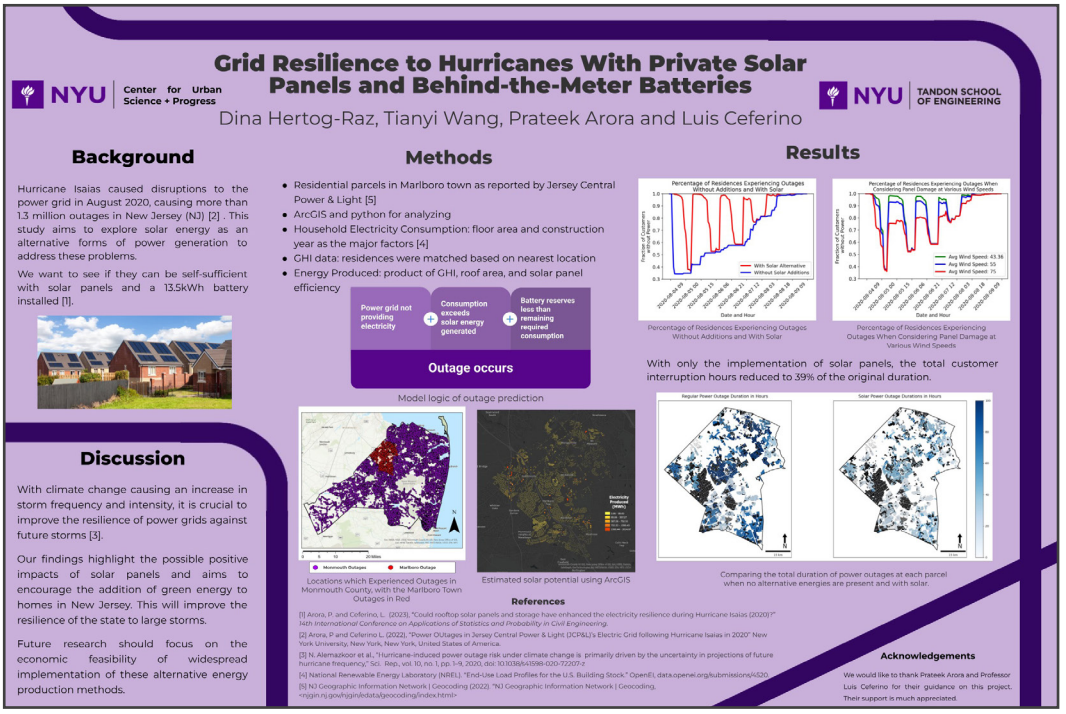


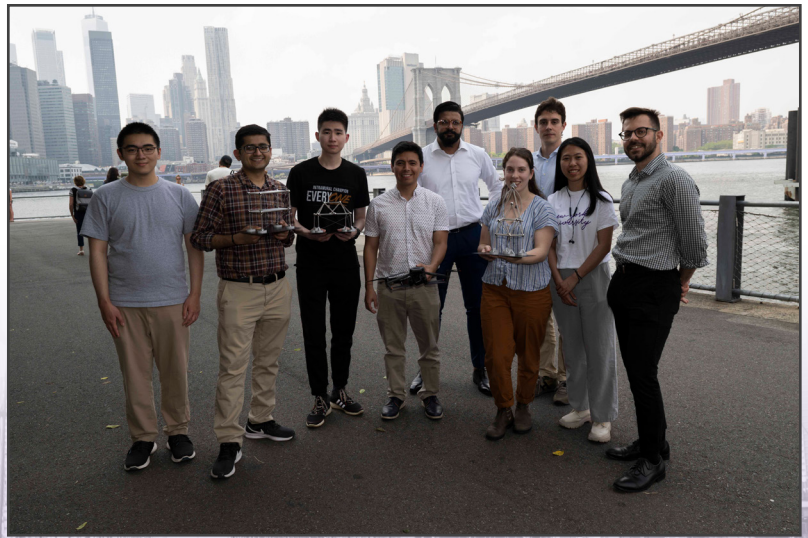
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PREDICTING UNDERGROUND UTILITY MAPS USING MACHINE LEARNING AND GRAPH THEORY

New York City (NYC) currently faces a lack of comprehensive information about its underground utility infrastructure. The absence of accurate underground infrastructure maps can result in construction delays, as utilities may only be discovered during excavation. Therefore, the goal of this project is to develop a data engineering pipeline to predict the underground utility pipe routings based on available open-source data about the locations of above-ground utilities. The first part of the project explores automatic and semi-automatic feature extraction techniques for the digitization of utility data from historic Sanborn maps. A variety of machine learning computer vision models including Random Forest, Support Vector Machine, Unclassified Learning, and Hough Transform were used to create a digital map of the city's above-ground infrastructure. The second part of the project uses these detected above-ground locations of fire hydrants from open-source data to create a network of the underground water pipes of NYC. Several graph theory algorithms are utilized to create a minimum spanning tree that represents the underground infrastructure, in which each node of the graph represents a fire hydrant, and the edges represent the underground water pipes that connect them. The final product is a comprehensive and accurate map of the underground water pipes of NYC, which can be used in construction projects to reduce excavation risks.

Project Supervisor: Debra Laefer (CUE); **Research Staff:** Charan Kukunoor; **Other Collaborators:** Wenqi Liao, Jasper Hall

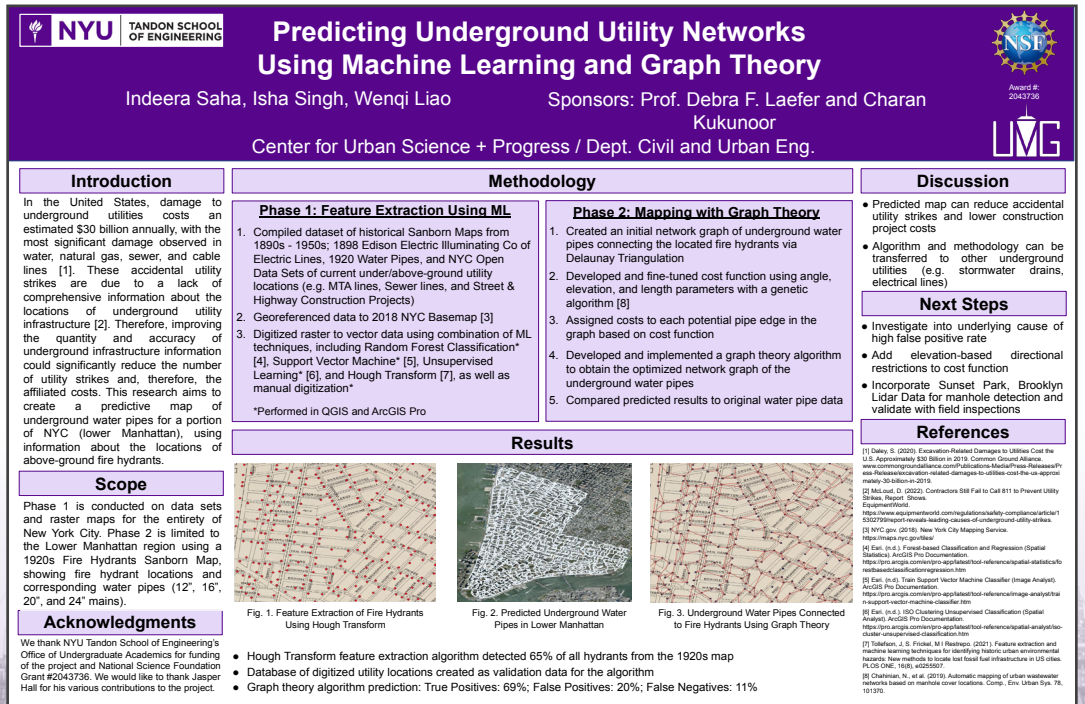
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NYU TANDON SCHOOL OF ENGINEERING

Predicting Underground Utility Networks Using Machine Learning and Graph Theory

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Sponsors: Prof. Debra F. Laefer and Charan Kukunoor

Center for Urban Science + Progress / Dept. Civil and Urban Eng.

NSF Award #: 2043736

Introduction

In the United States, damage to underground utilities costs an estimated $30 billion annually, with the most significant damage observed in water, natural gas, sewer, and cable lines [1]. These accidental utility strikes are due to a lack of comprehensive information about the locations of underground utility infrastructure [2]. Therefore, improving the quantity and accuracy of underground infrastructure information could significantly reduce the number of utility strikes and, therefore, the affiliated costs. This research aims to create a predictive map of underground water pipes for a portion of NYC (lower Manhattan), using information about the locations of above-ground fire hydrants.

Scope

Phase 1 is conducted on data sets and raster maps for the entirety of New York City. Phase 2 is limited to the Lower Manhattan region using a 1920s Fire Hydrants Sanborn Map, showing fire hydrant locations and corresponding water pipes (12", 16", 20", and 24" mains).

Acknowledgments

We thank NYU Tandon School of Engineering's Office of Undergraduate Academics for funding of the project and National Science Foundation Grant #2043736. We would like to thank Jasper Hall for his various contributions to the project.

Methodology

Phase 1: Feature Extraction Using ML

1. Compiled dataset of historical Sanborn Maps from 1890s - 1950s; 1898 Edison Electric Illuminating Co of Electric Lines, 1920 Water Pipes, and NYC Open Data Sets of current under/above-ground utility locations (e.g. MTA lines, Sewer lines, and Street & Highway Construction Projects)
2. Georeferenced data to 2018 NYC Basemap [3]
3. Digitized raster to vector data using combination of ML techniques, including Random Forest Classification* [4], Support Vector Machine* [5], Unsupervised Learning* [6], and Hough Transform [7], as well as manual digitization*

*Performed in QGIS and ArcGIS Pro

Phase 2: Mapping with Graph Theory

1. Created an initial network graph of underground water pipes connecting the located fire hydrants via Delaunay Triangulation
2. Developed and fine-tuned cost function using angle, elevation, and length parameters with a genetic algorithm [8]
3. Assigned costs to each potential pipe edge in the graph based on cost function
4. Developed and implemented a graph theory algorithm to obtain the optimized network graph of the underground water pipes
5. Compared predicted results to original water pipe data

Results

Fig. 1. Feature Extraction of Fire Hydrants Using Hough Transform

Fig. 2. Predicted Underground Water Pipes in Lower Manhattan

Fig. 3. Underground Water Pipes Connected to Fire Hydrants Using Graph Theory

- Hough Transform feature extraction algorithm detected 65% of all hydrants from the 1920s map
- Database of digitized utility locations created as validation data for the algorithm
- Graph theory algorithm prediction: True Positives: 69%; False Positives: 20%; False Negatives: 11%

Discussion

- Predicted map can reduce accidental utility strikes and lower construction project costs
- Algorithm and methodology can be transferred to other underground utilities (e.g. stormwater drains, electrical lines)

Next Steps

- Investigate into underlying cause of high false positive rate
- Add elevation-based directional restrictions to cost function
- Incorporate Sunset Park, Brooklyn Lidar Data for manhole detection and validate with field inspections

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QUANTIFYING TREE CANOPY RAINFALL INTERCEPTION AND STORAGE THROUGH OPEN DATA ANALYSIS

Unprecedented pluvial flooding in urban areas has brought into question the accuracy of urban flood models, which do not always consider the impact of tree canopy. Trees mitigate pluvial flooding primarily through rainfall interception. Interception depends on surface water storage capacity, which depends on individual tree characteristics. Some existing interception models use storage capacity calculations that require many individual tree measurements and are thus not easily scalable to a large area. Others generalize storage over large areas of canopy without accounting for interspecies differences. This study quantifies the surface water storage capacity of 98,700 trees in southwest Brooklyn using individual tree features extracted from two open datasets: the 2015 NYC Street Tree Census and a LiDAR-based structure mapping of NYC trees. Bark and foliar surface areas were approximated from these features, and then multiplied by genus-specific water storage capacities to calculate the water storage per block. The total water storage capacity of the study area is approximately 1.7 million liters. Water storage capacity per block was visualized in a GIS and the storage per square meter of canopy was displayed in a raster. This raster can be used as an input in interception and precipitation models to evaluate the impact of tree cover on pluvial flooding.

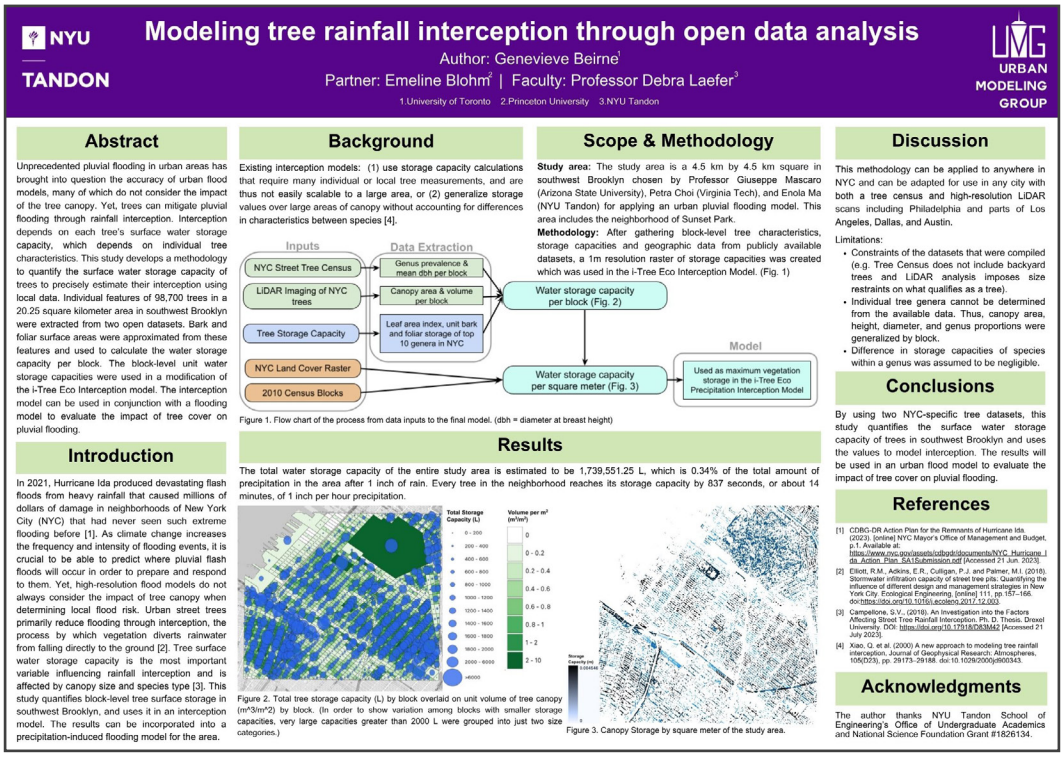
Project Supervisor: Debra Laefer (CUE); **Other Collaborators:** Emeline Blohm

Research Areas: *Urban, Data Science/AI/Robotics*



Genevieve Beirne
Mechanical Engineering, B.S., 2026
University of Toronto

Visiting Student Fellow



NYU TANDON

Modeling tree rainfall interception through open data analysis

Author: Genevieve Beirne[1]
Partner: Emeline Blohm[2] | Faculty: Professor Debra Laefer[3]
1.University of Toronto 2.Princeton University 3.NYU Tandon

URBAN MODELING GROUP

Abstract

Unprecedented pluvial flooding in urban areas has brought into question the accuracy of urban flood models, many of which do not consider the impact of the tree canopy. Yet, trees can mitigate pluvial flooding through rainfall interception. Interception depends on each tree's surface water storage capacity, which depends on individual tree characteristics. This study develops a methodology to quantify the surface water storage capacity of trees to precisely estimate their interception using local data. Individual features of 98,700 trees in a 20.25 square kilometer area in southwest Brooklyn were extracted from two open datasets. Bark and foliar surface areas were approximated from these features and used to calculate the water storage capacity per block. The block-level unit water storage capacities were used in a modification of the i-Tree Eco Interception model. The interception model can be used in conjunction with a flooding model to evaluate the impact of tree cover on pluvial flooding.

Introduction

In 2021, Hurricane Ida produced devastating flash floods from heavy rainfall that caused millions of dollars of damage in neighborhoods of New York City (NYC) that had never seen such extreme flooding before [1]. As climate change increases the frequency and intensity of flooding events, it is crucial to be able to predict where pluvial flash floods will occur in order to prepare and respond to them. Yet, high-resolution flood models do not always consider the impact of tree canopy when determining local flood risk. Urban street trees primarily reduce flooding through interception, the process by which vegetation diverts rainwater from falling directly to the ground [2]. Tree surface water storage capacity is the most important variable influencing rainfall interception and is affected by canopy size and species type [3]. This study quantifies block-level tree surface storage in southwest Brooklyn, and uses it in an interception model. The results can be incorporated into a precipitation-induced flooding model for the area.

Background

Existing interception models: (1) use storage capacity calculations that require many individual or local tree measurements, and are thus not easily scalable to a large area, or (2) generalize storage values over large areas of canopy without accounting for differences in characteristics between species [4].

Figure 1. Flow chart of the process from data inputs to the final model. (dbh = diameter at breast height)

Scope & Methodology

Study area: The study area is a 4.5 km by 4.5 km square in southwest Brooklyn chosen by Professor Giuseppe Mascaro (Arizona State University), Petra Choi (Virginia Tech), and Enola Ma (NYU Tandon) for applying an urban pluvial flooding model. This area includes the neighborhood of Sunset Park.

Methodology: After gathering block-level tree characteristics, storage capacities and geographic data from publicly available datasets, a 1m resolution raster of storage capacities was created which was used in the i-Tree Eco Interception Model. (Fig. 1)

Results

The total water storage capacity of the entire study area is estimated to be 1,739,551.25 L, which is 0.34% of the total amount of precipitation in the area after 1 inch of rain. Every tree in the neighborhood reaches its storage capacity by 837 seconds, or about 14 minutes, of 1 inch per hour precipitation.

Figure 2. Total tree storage capacity (L) by block overlaid on unit volume of tree canopy (m^3/m^2) by block. (In order to show variation among blocks with smaller storage capacities, very large capacities greater than 2000 L were grouped into just two size categories.)

Figure 3. Canopy Storage by square meter of the study area.

Discussion

This methodology can be applied to anywhere in NYC and can be adapted for use in any city with both a tree census and high-resolution LiDAR scans including Philadelphia and parts of Los Angeles, Dallas, and Austin.

Limitations:

- Constraints of the datasets that were compiled (e.g. Tree Census does not include backyard trees and LiDAR analysis imposes size restraints on what qualifies as a tree).
- Individual tree genera cannot be determined from the available data. Thus, canopy area, height, diameter, and genus proportions were generalized by block.
- Difference in storage capacities of species within a genus was assumed to be negligible.

Conclusions

By using two NYC-specific tree datasets, this study quantifies the surface water storage capacity of trees in southwest Brooklyn and uses the values to model interception. The results will be used in an urban flood model to evaluate the impact of tree cover on pluvial flooding.

References

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[4] Xiao, Q. et al. (2000) A new approach to modeling tree rainfall interception, Journal of Geophysical Research: Atmospheres, 105(D23), pp. 29173–29188. doi:10.1029/2000jd900343.

Acknowledgments

The author thanks NYU Tandon School of Engineering's Office of Undergraduate Academics and National Science Foundation Grant #1826134.

ROADWAY FLOOD DETECTION MODEL USING COMPUTER VISION

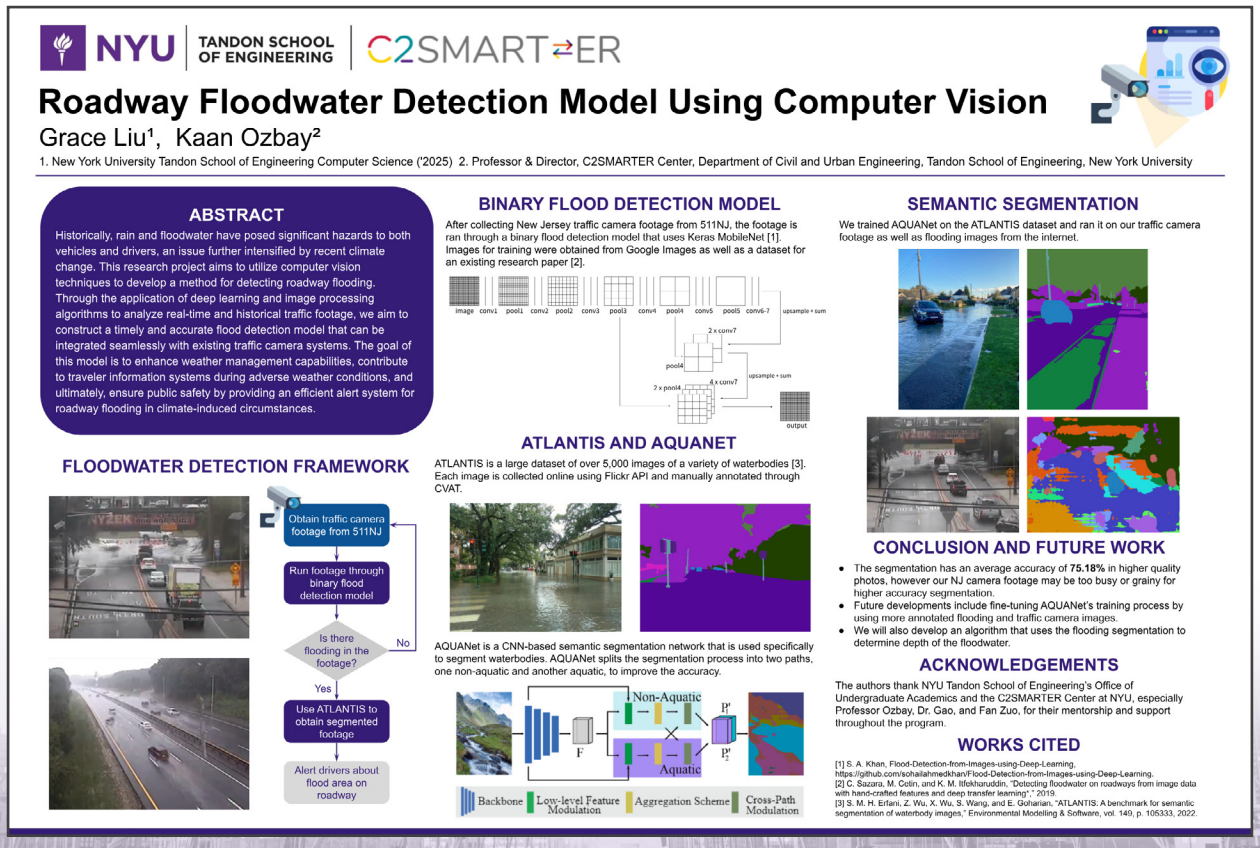
Historically, rain and floodwater have posed significant hazards to both vehicles and drivers, risks that have been intensified by recent climate-change-induced extreme weather events. This research project aims to utilize computer vision techniques to develop a method for detecting roadway flooding. Through the application of deep learning and image processing algorithms to analyze real-time and historical traffic footage, we aim to construct a timely and accurate flood detection model that can be integrated seamlessly with existing traffic camera systems. The goal of this model is to enhance weather management capabilities, contribute to traveler information systems during adverse weather conditions, and ultimately, ensure public safety by providing an efficient alert system for roadway flooding in climate-induced circumstances.

Project Supervisor: Kaan Ozbay (CUE, CUSP); **Research Staff:** Fan Zuo, Jingqin Gao

Research Areas: *Urban, Data Science/AI/Robotics, Cybersecurity*



Grace Liu
Computer Science, B.S., 2025
NYU Tandon School of Engineering



VISUALIZING DEEP LEARNING MODEL PREDICTIONS OF ROADWAY WORKERS' 3D TRAJECTORY

Developing accurate deep learning models that predict how roadway construction workers will behave as they work can lead to a better understanding of worker safety and innovative technologies that improve it. Such models can specifically predict a worker's trajectory, how they will move in the future, based on their past behavior. Visualizing these trajectories, both how a worker's body moves and how they turn their heads, are critical to evaluating how accurate the deep learning models are in their predictions. Going beyond conventional 2D plots, this study presents a technique to animate a model's predicted trajectories in 3D within the Unity engine. Prior work to this study invited people to perform simulated roadwork in virtual reality (VR) experiments and trained deep learning models on collected trajectory data. The outcomes of this study have significant implications for improving construction worker safety by offering an authentic representation of roadway behavior in VR simulations, potentially identifying hazardous actions, and enabling preventative measures.

Project Supervisor: Semiha Ergan (CUE)

Research Areas: *Urban, Data Science/AI/Robotics*



Ahmed Elsaid
Computer Engineering, B.S., 2024
NYU Abu Dhabi

NYU TANDON SCHOOL OF ENGINEERING

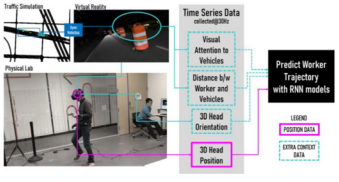
Visualizing Deep Learning Model Predictions of Roadway Workers' 3D Trajectory

Ahmed Elsaid [1], Daniel Lu [2], Semiha Ergan [2]

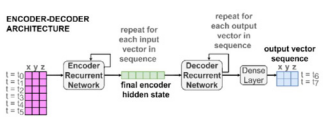
1. NYU Abu Dhabi Department of Engineering 2. NYU Tandon School of Engineering

Background

To better understand how roadway workers behave to maintain their safety, prior work to this study invited people to perform simulated roadwork in virtual reality (VR) experiments and trained deep learning models on collected trajectory data.



A RNN trajectory prediction model was trained with 2 different conditions: with context (vehicles seen and distance with vehicles) and without context (only position and orientation data).



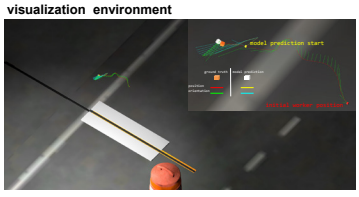
Approach

Going beyond conventional 2D plots, this study presents a technique to animate a model's predicted trajectories in 3D within the same realistic VR environment as the experiment, where the participants were performing a roadway sensor installation task.

experiment VR environment



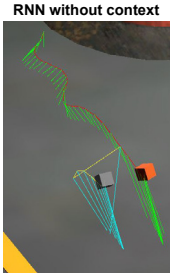
visualization environment



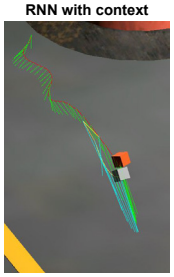
Results

A comparison between the 2 different RNN models was drawn using the 3D visualization:

RNN without context



RNN with context



Contributions

These 3D data visualizations help develop worker models to generate authentic representations of roadway behavior in safety simulations, which can be utilized to identify hazardous worker actions, and evaluate preventative measures.

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.

FACULTY

Shivendra Panwar (ECE)
Davood Shahrjerdi (ECE)



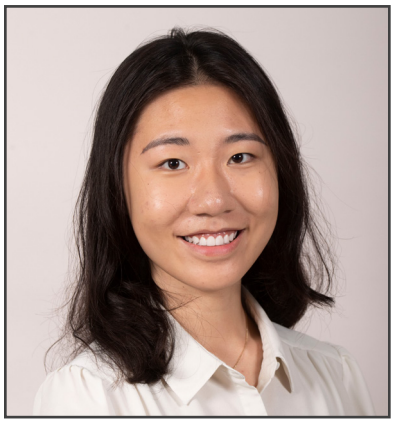
LEARN MORE

CHARACTERIZING LATENCY PERFORMANCE IN US CELLULAR NETWORKS

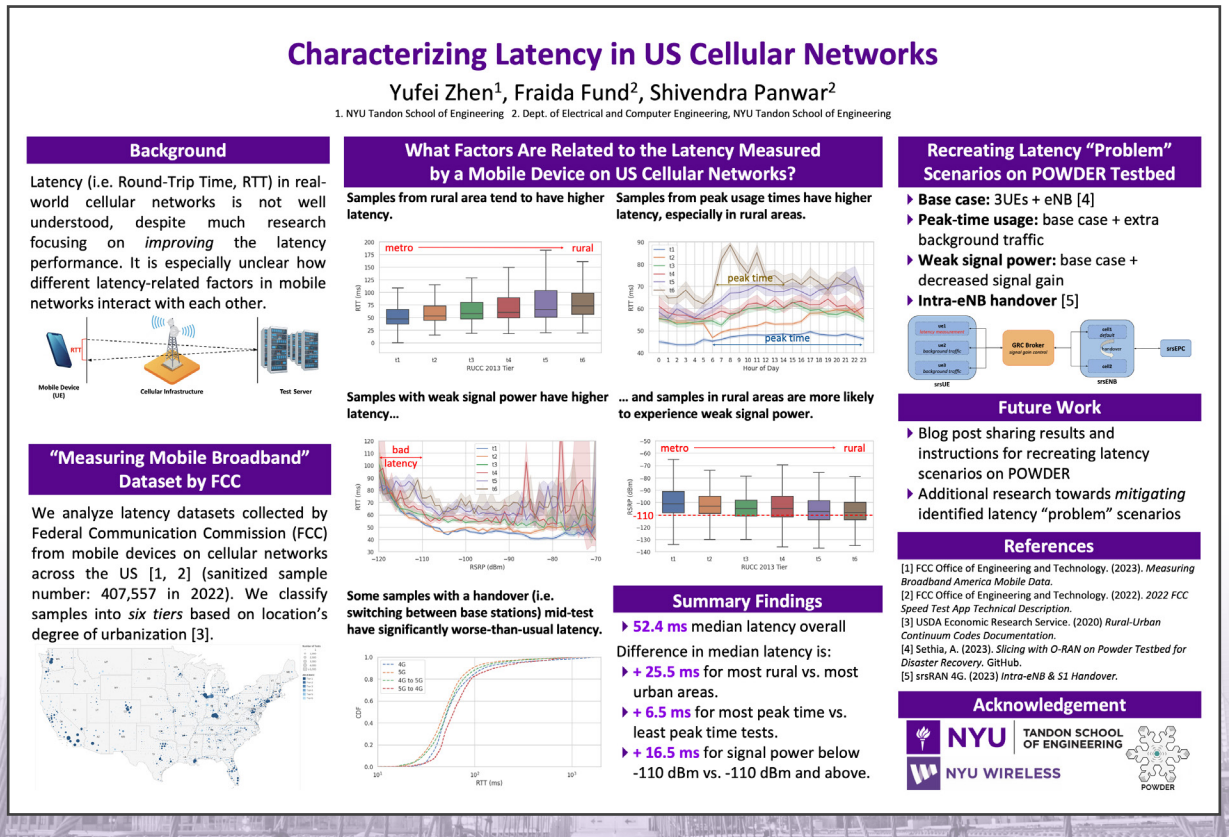
Despite much research focusing on improving the latency performance of cellular networks, the status quo experienced by users of real-world networks in the United States today is not well understood. In this project, we analyze latency measurements collected by the FCC from mobile devices on cellular networks across the United States over the past three years. Through this data, we identify the 'typical' latency performance, as well as specific factors that are related to worse-than-usual latency: low signal strength, usage during peak times, and handover. We further characterize the interaction of these factors with other relevant conditions (e.g., metropolitan vs. non-metropolitan location). Next, we recreate these 'problem' scenarios in an emulated cellular network experiment on the POWDER research platform. We share the results of the data analysis and the reference experiments on POWDER to help advance future research on low latency cellular networks.

Project Supervisor: Shivendra Panwar (ECE); **Research Staff:** Fraida Fund

Research Areas: *Wireless*



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NYU Tandon School of Engineering



EFFECTS OF BUFFER CONCENTRATION ON NEUROTRANSMITTER DETECTION WITH NANO-BIOSENSORS

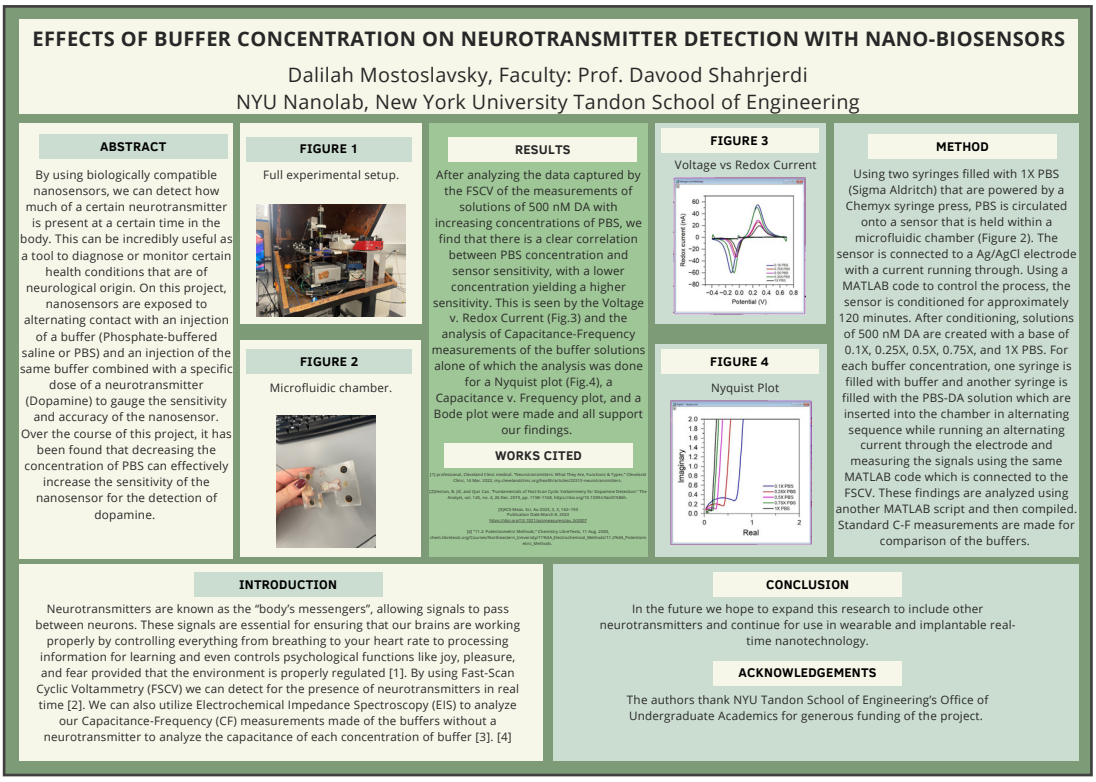
Neurotransmitters are known as the “body’s messengers”, allowing signals to pass between neurons. These signals are essential for ensuring that our brains are working properly by controlling everything from breathing to your heart rate to processing information for learning and even controls psychological functions like joy, pleasure, and fear. When certain neurotransmitters are missing or are overly abundant, causing a neurotransmitter imbalance, this can lead to disastrous neurological and psychological consequences within our bodies. By using biologically compatible nanosensors, we can detect how much of a certain neurotransmitter is present at a certain time in the body. This can be incredibly useful as a tool to diagnose or monitor certain health conditions that are of neurological origin. On this project, nanosensors are exposed to alternating contact with an injection of a buffer (Phosphate-buffered saline or PBS) and an injection of the same buffer combined with a specific dose of a neurotransmitter (Dopamine) to gauge the sensitivity and accuracy of the nanosensor. Over the course of this project, it has been found that decreasing the concentration of PBS can effectively increase the sensitivity of the nanosensor for the detection of dopamine.

Project Supervisor: Davood Shahrjerdi (ECE)

Research Areas: *Wireless*



Dalilah Mostoslavsky
Mechanical Engineering, B.S., 2025
NYU Tandon School of Engineering



EFFECTS OF BUFFER CONCENTRATION ON NEUROTRANSMITTER DETECTION WITH NANO-BIOSENSORS

Dalilah Mostoslavsky, Faculty: Prof. Davood Shahrjerdi
NYU Nanolab, New York University Tandon School of Engineering

ABSTRACT

By using biologically compatible nanosensors, we can detect how much of a certain neurotransmitter is present at a certain time in the body. This can be incredibly useful as a tool to diagnose or monitor certain health conditions that are of neurological origin. On this project, nanosensors are exposed to alternating contact with an injection of a buffer (Phosphate-buffered saline or PBS) and an injection of the same buffer combined with a specific dose of a neurotransmitter (Dopamine) to gauge the sensitivity and accuracy of the nanosensor. Over the course of this project, it has been found that decreasing the concentration of PBS can effectively increase the sensitivity of the nanosensor for the detection of dopamine.

FIGURE 1

Full experimental setup.

FIGURE 2

Microfluidic chamber.

RESULTS

After analyzing the data captured by the FSCV of the measurements of solutions of 500 nM DA with increasing concentrations of PBS, we find that there is a clear correlation between PBS concentration and sensor sensitivity, with a lower concentration yielding a higher sensitivity. This is seen by the Voltage v. Redox Current (Fig.3) and the analysis of Capacitance-Frequency measurements of the buffer solutions alone of which the analysis was done for a Nyquist plot (Fig.4), a Capacitance v. Frequency plot, and a Bode plot were made and all support our findings.

WORKS CITED

FIGURE 3

Voltage vs Redox Current

FIGURE 4

Nyquist Plot

METHOD

Using two syringes filled with 1X PBS (Sigma Aldritch) that are powered by a Chemyx syringe press, PBS is circulated onto a sensor that is held within a microfluidic chamber (Figure 2). The sensor is connected to a Ag/AgCl electrode with a current running through. Using a MATLAB code to control the process, the sensor is conditioned for approximately 120 minutes. After conditioning, solutions of 500 nM DA are created with a base of 0.1X, 0.25X, 0.5X, 0.75X, and 1X PBS. For each buffer concentration, one syringe is filled with buffer and another syringe is filled with the PBS-DA solution which are inserted into the chamber in alternating sequence while running an alternating current through the electrode and measuring the signals using the same MATLAB code which is connected to the FSCV. These findings are analyzed using another MATLAB script and then compiled. Standard C-F measurements are made for comparison of the buffers.

INTRODUCTION

Neurotransmitters are known as the “body’s messengers”, allowing signals to pass between neurons. These signals are essential for ensuring that our brains are working properly by controlling everything from breathing to your heart rate to processing information for learning and even controls psychological functions like joy, pleasure, and fear provided that the environment is properly regulated [1]. By using Fast-Scan Cyclic Voltammetry (FSCV) we can detect for the presence of neurotransmitters in real time [2]. We can also utilize Electrochemical Impedance Spectroscopy (EIS) to analyze our Capacitance-Frequency (CF) measurements made of the buffers without a neurotransmitter to analyze the capacitance of each concentration of buffer [3]. [4]

CONCLUSION

In the future we hope to expand this research to include other neurotransmitters and continue for use in wearable and implantable real-time nanotechnology.

ACKNOWLEDGEMENTS

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

LEARNING BY REPRODUCING FOUNDATIONAL RESULTS IN COMMUNICATION NETWORKS

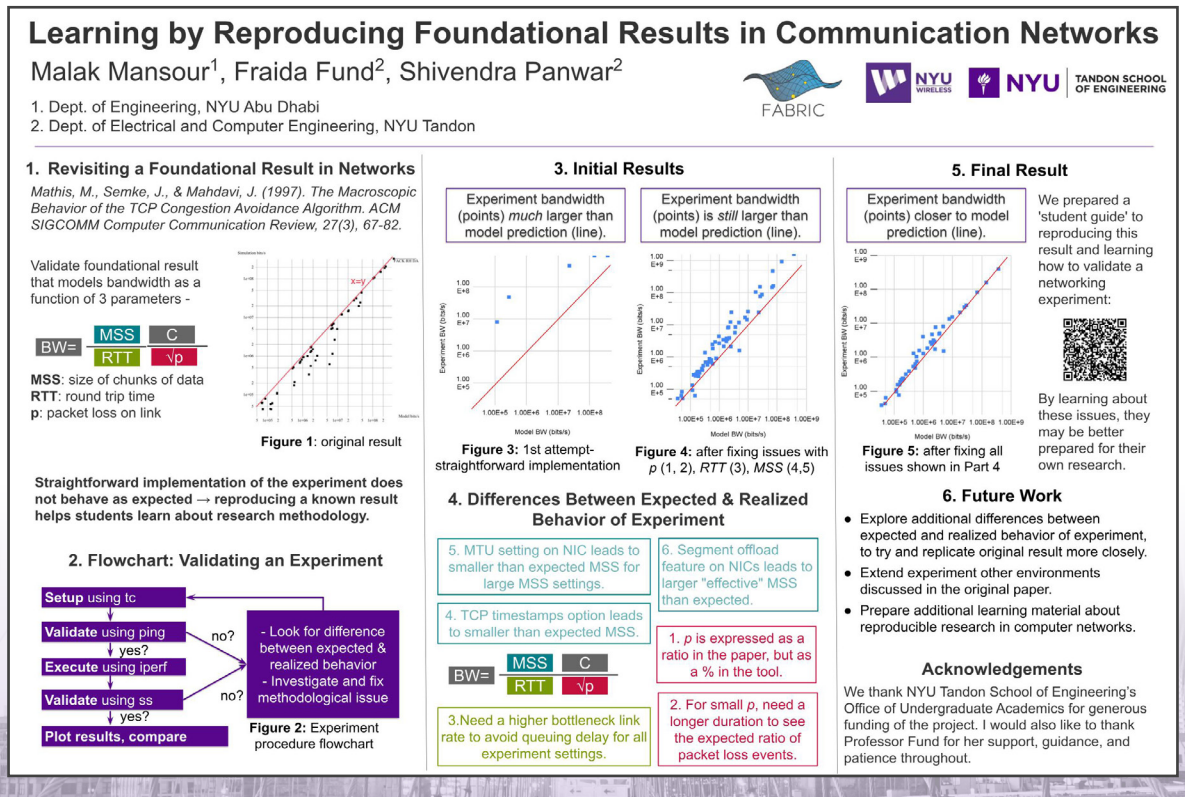
In the field of communication networks, experimental research using real networks and real implementations of network protocols is prone to subtle errors, because of differences between what the researcher expects that the experiment does and its actual behavior. This can lead to accidental publication of results that are not valid in the intended setting. As an example, we used a straightforward experimental approach to reproduce a foundational result from 1997, but because of some of these 'hidden' differences, our result was different from the original by several orders of magnitude. To help researchers in communication networks learn to identify these errors and design better experiments, we develop a tutorial in which we show by example how we identify and correct the mistakes in the previously-mentioned attempt to reproduce a foundational result. In our final, 'validated' experiment, we achieve results much more similar to the original published result. We hope that through this resource, researchers will be better prepared to identify hidden pitfalls in their experiments, correct them, and publish valid results.

Project Supervisor: Shivendra Panwar (ECE); **Research Staff:** Fraida Fund

Research Areas: *Wireless, Data Science/AI/Robotics*



Malak Mansour
Electrical Engineering, B.S., 2024
NYU Abu Dhabi



WIRELESS SIGNAL LOCALIZATION WITH AN AUTONOMOUS UAV ON AERPAW

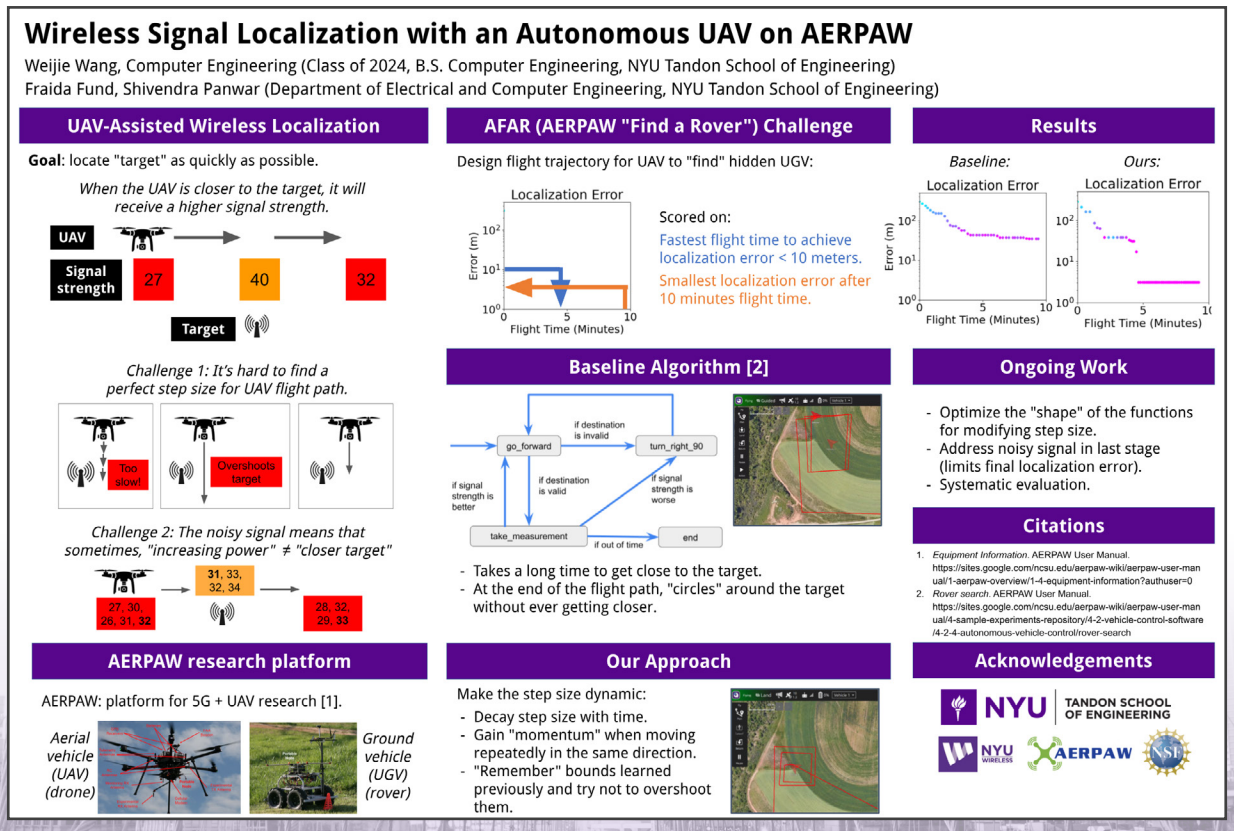
UAV-assisted wireless localization, where a UAV (unmanned aerial vehicle) locates a target using a wireless signal, has important applications including search and rescue. However, deciding the autonomous UAV trajectory in real time to locate the target precisely and quickly remains challenging. In this project, we implement a wireless localization scenario on AERPAW, a research platform for studying the convergence of 5G technology and UAVs. We design a trajectory update algorithm that dynamically adjusts the step size of the UAV based on the long-term and recent progress of the search, in order to reduce the search time. Our design also uses bounding boxes of decreasing size, which are updated as the UAV gets new information from the wireless signal, to limit the search space. Compared to the baseline algorithm on AERPAW, our design localizes the target more precisely after 10 minutes of searching, and localizes the target within 10 meters more quickly.

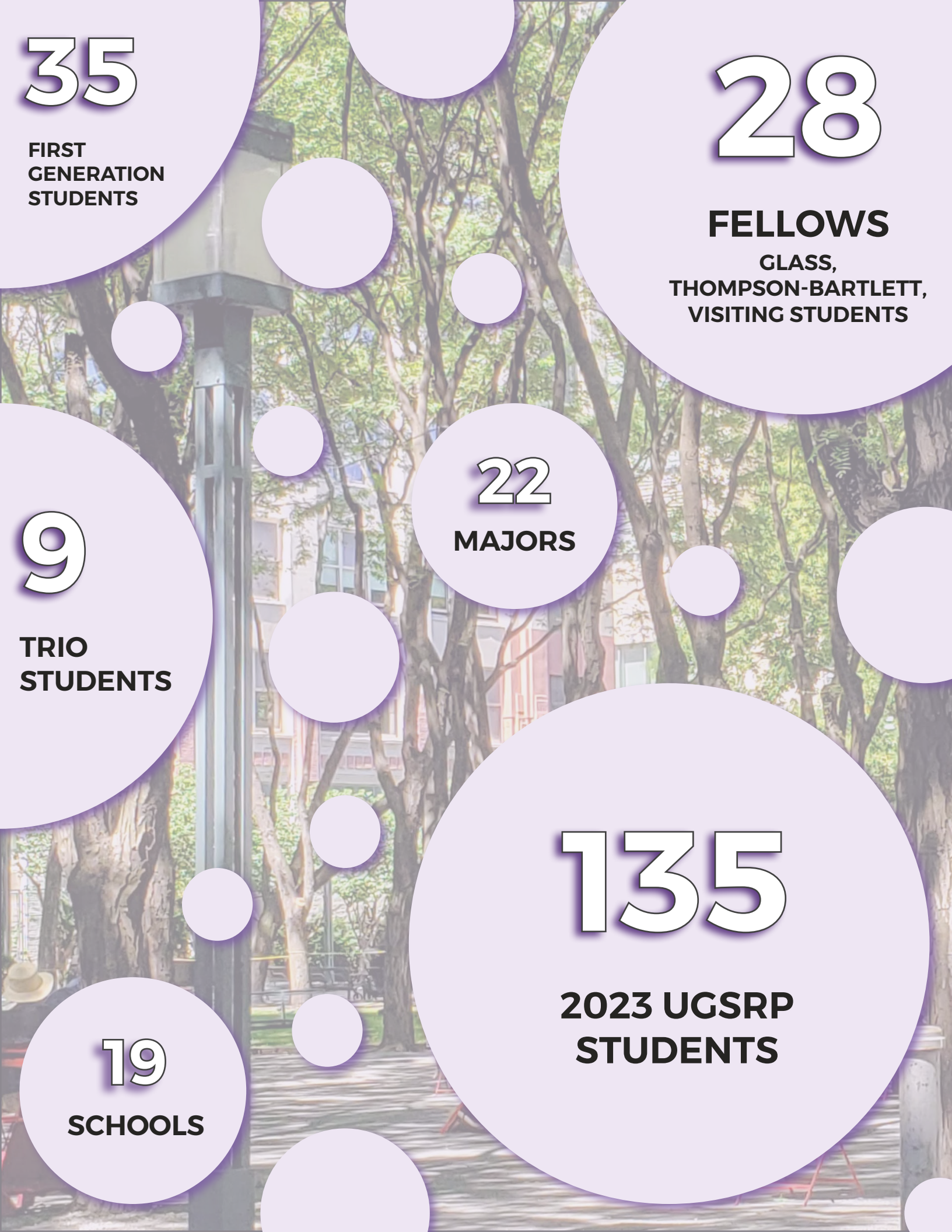
Project Supervisor: Shivendra Panwar (ECE); **Research Staff:** Fraida Fund

Research Areas: *Wireless*



Weijie Wang
Computer Engineering, B.S., 2023
NYU Tandon School of Engineering





35

FIRST GENERATION STUDENTS

28

FELLOWS

GLASS, THOMPSON-BARTLETT, VISITING STUDENTS

22

MAJORS

9

TRIO STUDENTS

135

2023 UGSRP STUDENTS

19

SCHOOLS

A SPECIAL MESSAGE FROM THE PROGRAM COORDINATORS

The Tandon Undergraduate Summer Research Program (UGSRP) was initiated at NYU Tandon in 2007. The Office of Undergraduate Academics (UGA) has coordinated the program since 2011. We are responsible for the expansion of the program from 60 student participants to well over 100, as well as faculty expansion that includes professors and research projects from NYU Wireless, the NYU Center for Urban Science and Progress, NYU Langone, as well as the Center of Faculty Innovations in Teaching and Learning, the Makerspace and various VIP projects. We have worked tirelessly to match the students with their best suited faculty mentors and research staff members in order to ensure fruitful participation and mentorshop. We have also dedicated time and effort to provide academic, career, and personal development seminars, lectures, workshops, and events so that students come out of the program with enhanced knowledge of both their research area and various opportunities and paths as they move forward in their professional trajectories. We have dedicated ourselves to this program and made sure to develop, maintain, and enhance it at every turn. We are thankful for all of those that joined in on this summer's program and assisted us to ensure a seamless program from start to finish. We congratulate all of the student participants on a successful summer and hope you enjoyed our program.



SARA-LEE RAMSAWAK
Senior Director of Academics, Programs, & Global Engagement



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