2024

ENGINEERING CAPSTONES


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NYUAD

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FOREWORD

MESSAGE FROM OUR DEAN

The Engineering Capstone is a major design course structured to immerse students in the process of developing engineering and technology solutions. It is a defining feature of the Engineering undergraduate experience that also provides the opportunity to integrate technical, societal, and aesthetic concerns with applied design solutions. The mission to create a design through imagination and innovation is leveraged from the knowledge and skills acquired throughout the four-year curriculum, together with the culmination of ideas from the Junior year and hard work throughout 2023-24.

This year's projects align with today's Engineering advances as well as our institutional research priorities of biomedical and health systems; cybersecurity; environmental sustainability; robotics and AI; and urban systems. The Capstone Festival is an opportunity for our Seniors to showcase their Capstone Projects incorporating design solutions to solve real world problems. The projects presented by the Class of 2024 are highlighted in this booklet; each represents the highest aspirations of undergraduate intellectual development, creativity, and engagement with original creative work.

To the Class of 2024, well done! Your projects are a testament to your incredible talent and hard work.

With offers to join top international graduate schools, take up positions in large corporations, enjoy gap years, or explore opportunities in the UAE, we wholeheartedly congratulate all of you on your wonderful academic achievements.

On behalf of the Engineering Division, our best wishes for a successful future ahead and please keep in touch!

Samer Madanat
Dean of Engineering
NYU Abu Dhabi

LETTER FROM THE CAPSTONE COORDINATOR

The real world engineering problems are cross-disciplinary in nature with diffuse boundaries between them. The strength of our undergraduate engineering programs (Civil Engineering, Mechanical Engineering, Electrical Engineering, Computer Engineering, Bioengineering and General Engineering) is in developing engineers to solve such real world problems. At NYUAD, the capstone courses, namely, Senior Design Capstone Project I (ENGR-UH-4011) and Senior Design Capstone Project II (ENGR-UH-4020), are structured to fulfill the requirements of all engineering programs/majors simultaneously. The scope of the challenge is defined and the execution process is structured such that each team member satisfies the requirements of their individual program.

The capstone program experience is designed to educate the students on the core principles of the staged gate process of project management, an established industry standard. Capstone coordinators and faculty advisors collectively work together to manage expectations and set challenging yet realistic project goals to enhance the quality of the program. Program content and processes are developed to ensure that capstone requirements are fulfilled to meet the ABET and Commission for Academic Accreditation (CAA) standards.

The goal of the Capstone Design Project is to provide students with a major design experience that leverages the knowledge and skills acquired through their undergraduate studies and co-curricular experiences. Its staged gate process structure includes a process of design with measurable metrics, and incorporation of appropriate engineering standards and multiple realistic constraints. Emphasis is placed on clearly framing the design problem and following the design process to result in an optimized design solution. Students are encouraged to build prototypes of their designs and seek validation of their solutions through simulations and experiments, as appropriate.

The emphasis is on students applying the design process to solve real-world problems in a 21st century, global context. The projects address engineering and technology topics that overlap with the sciences, social sciences, liberal arts or business. The Capstone provides an opportunity to integrate technical, human, aesthetic, business and ethical concerns with engineering design. Students practice critical skills in communication, team-building, and project management. Students complete their design and build/test their prototypes, if applicable, during the spring semester. The senior year culminates in a comprehensive project report.

Senior Design Capstone Project I (ENGR-UH-4011) and Senior Design Capstone Project II (ENGR-UH-4020) collectively offer the engineering capstone experience to seniors. Senior Design Capstone Project I is two credits which runs for the whole of fall semester. Senior Design Capstone Project I focus on different aspects of the capstone project such as problem definition and creating the design solution. Senior Design Capstone Project II in spring consists of two, seven week modules. The design solution proposed in Senior Design Capstone Project I is implemented in the first module. It is tested and validated in Module II.

This year there are 64 senior students working on capstone projects. For some projects there are multiple groups working on the same topic. The titles of the projects are listed below:

1. **A Self-Powered Desalination Unit with Dual Modes of Operation: Design of desalination plant**
2. **A self-powered desalination unit with dual modes of operation: Wave Power capture and storage**
3. **A self-powered desalination unit with dual modes of operation: Solar power capture**
4. **Enhancing Wingtip Vortex Turbine efficiency through drag minimization and optimal placement**
5. **Bioengineered Small Diameter Vascular Grafts (SDVG) to Address Unmet Clinical Needs**
6. **Targeted Receptor-based Irinotecan and Oxaliplatin Delivery to GastroIntestinal Tumors (TRI-GIT)**
7. **Design and Sustainability solutions for a Sea Port**
8. **Design, Implementation, and Control of an Amphibious Submersible Vehicle**
9. **Design of Low Cost NeoNatal Incubator**
10. **An Automated optimization framework for fast and energy-efficient inference of multimodal large language models (MLLMs) targeting embedded devices**

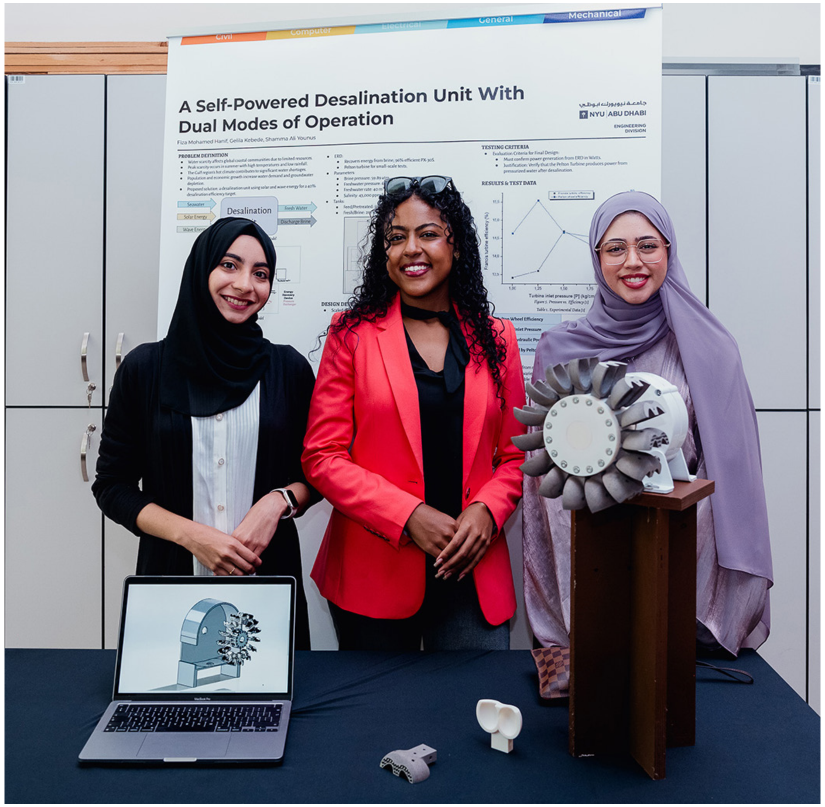
I take this opportunity to congratulate all the teams on their successful completion of the capstone projects and wish them all the best in their future endeavors.

Sincerely,

Pradeep George, PhD
Clinical Associate Professor and Coordinator of Engineering Capstones
NYU Abu Dhabi

CAPSTONE PROJECTS

A Self-Powered Desalination Unit with Dual Modes of Operation | Group A



Fiza Mohamed Hanif (MechE), Gelila Kebede (MechE) and Shamma Ali Younus (MechE)

Water constitutes one of the most abundant resources globally, making up approximately three-quarters of the Earth's surface. Nevertheless, numerous countries, particularly in Africa and the Middle East, face severe shortages of potable water. To tackle the problem of water scarcity, it is imperative to adopt innovative, compact, sustainable, and cost-efficient approaches to desalinate seawater. Hence, this proposal delves into the conceptual design process of a water desalination system powered

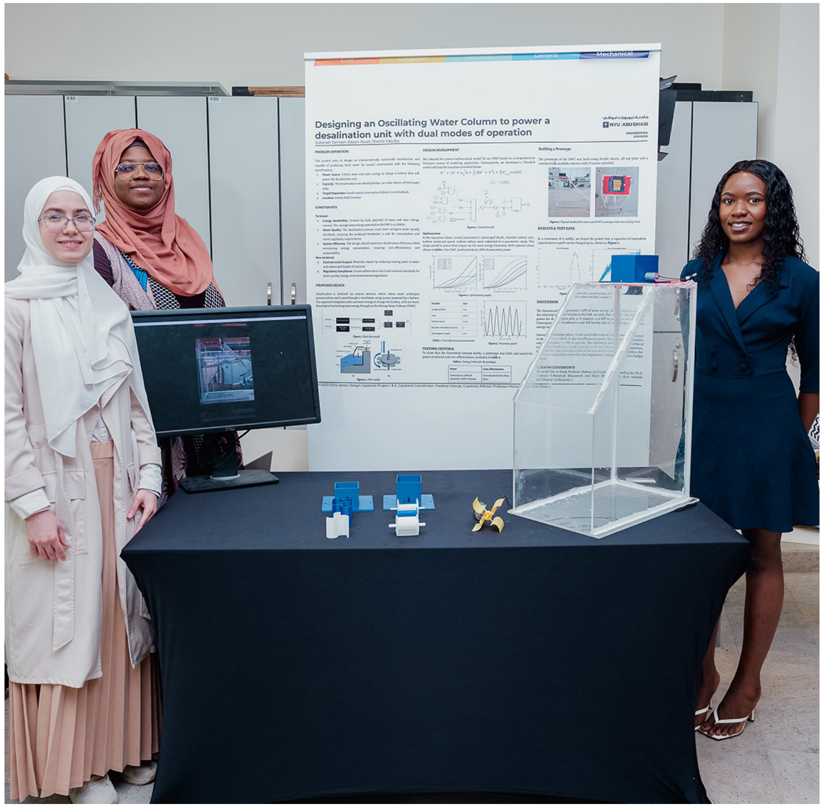
by solar and wave energy. Solar energy via lithium-ion batteries is used as a source of power to pump water across the Reverse Osmosis Module ideally during sunny days. The second source of power utilizes the energy from waves using an oscillating water column, and comes in handy after sunset, on cloudy days when the sea has considerable waves. The desalination unit is scalable and can be utilized to sustainably meet the freshwater needs of water scarce communities. The proposed design sustains a community of 200 individuals by supplying 40 *m*3 of freshwater per day.

The unit functions as outlined herewith. Seawater from the Gulf is first pre-treated to bring down the turbidity and eliminate the presence of microorganisms, colloidal contaminants, as well as other unwanted solids, from the water. It is then passed through a Reverse Osmosis (RO) system, which brings the salinity down to acceptable levels for potable water. The reject brine from the RO process is then passed through an Energy Recovery Device (ERD), to recover energy from the brine as it remains pressurized after the RO process. The design tackles a global problem while ensuring that environment and energy sustainability are prioritized.

Capstone Advisor

Raed Hashaikeh, Professor of Mechanical Engineering

A Self-Powered Desalination Unit with Dual Modes of Operation | Group B



Jullie Tomson (MechE), Sherifa Yakubu (MechE) and Bayan Assali (MechE)

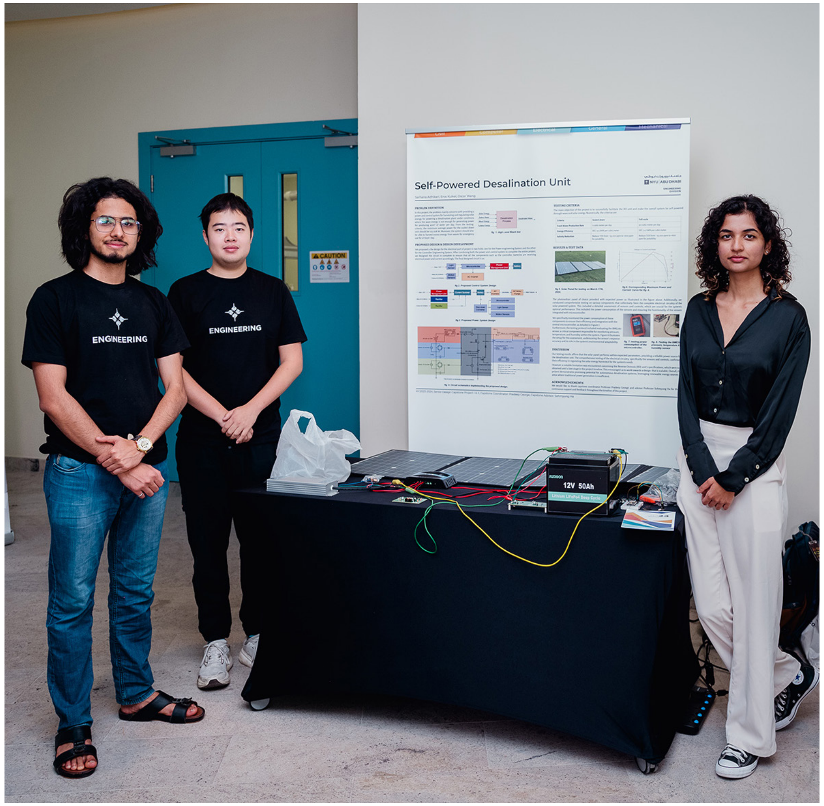
The primary goal of this capstone project is to design an environmentally sustainable desalination unit capable of producing fresh water for coastal communities that currently lack access to this vital resource. The system is designed to be scalable and is intended to provide a daily supply of 40 cubic meters of freshwater, sufficient to support a small community of approximately 200 individuals. To achieve this objective, the proposed desalination unit incorporates two distinct modes of energy generation: solar power and wave power. These energy sources can operate in tandem or independently to create the necessary pressure for pumping saline seawater through a reverse osmosis (RO) membrane, thereby generating the required daily freshwater output.

In the first mode, solar energy plays a central role by driving a pump powered by lithium-ion batteries. This pump efficiently pressurizes the saline water, allowing it to pass through the RO membrane, making it particularly effective in sunny daytime conditions. In the second mode, the system seamlessly switches to utilizing wave energy, which will be harvested using an Oscillating Water Column (OWC). This mode comes into play during cloudy days, after sunset, or when significant ocean waves are present. It harnesses the power of ocean waves through the OWC, ensuring a continuous supply of fresh water under various environmental conditions. In summary, the overarching aim of this capstone project is to create a versatile and sustainable desalination system capable of alleviating freshwater scarcity in coastal communities. By combining the complementary forces of solar and wave energy, with wave energy harvested through an OWC, this innovative solution guarantees a consistent and eco-friendly provision of fresh water.

Capstone Advisor

Mohammed Farid Daqaq, Professor of Mechanical Engineering

A Self-Powered Desalination Unit with Dual Modes of Operation | Group C



Sarhana Adhikari (ElecE), Eros Kuikel (ElecE), Oscar Wang (ElecE)

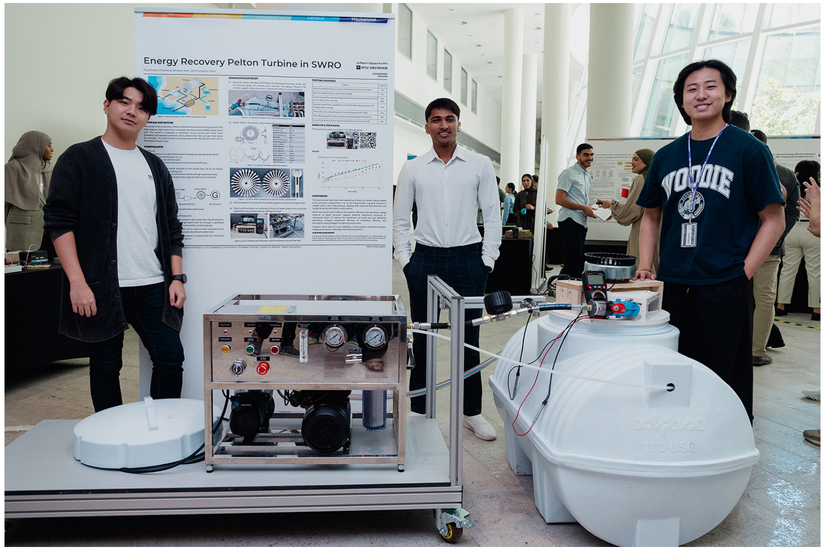
This capstone project aims to design a desalination unit that can be powered by solar and/or wave energy. The unit is scalable and can on average sustain a small (coastal) community of 200 individuals without access to fresh water by providing 40 m3 of fresh water per day. The two modes of energy generation (solar and wave) should be able to work either combined or separately to produce the pressure needed to pump the saline water through a reverse osmosis (RO) membrane and to produce the required daily fresh water supply.

The project requires the integration of mechanical and electrical subtasks. Electrical subtasks include designing the photovoltaic battery charging system and the operation controller using a microcontroller. For the photovoltaic battery charging system, selection and characterization of the solar panel is needed along with designing the battery charging electronics and power converters. As for the operation controller, designing the illumination condition detector and controller for the battery charger and power modes are needed along with designing the optimization algorithm for the PV energy harvesting.

Capstone Advisor

Sohmyung Ha, Assistant Professor of Electrical Engineering and Bioengineering

Desalination Power Plant



Sungho Yoon (GenE), Min Soo Kim (MechE) and Aryamaan Dholakia (MechE)

This project outlines the comprehensive design of a desalination unit employing a Reverse Osmosis (RO) membrane technology to yield 40m^3 of fresh water daily. The process encompasses a series of meticulously engineered stages, commencing with seawater intake from a 120 m^3 capacity tank, featuring an initial pre-treatment unit operating at up to 65 bar pressure for preliminary filtration.

Subsequent stages involve coagulation and flocculation units. A flow speed buffer maintains consistent flow rates before directing the pre-treated water into an Ultrafiltration (UF) system housed in a tank with identical pressure and capacity specifications.

The system's heart lies in the spiral-wound Reverse Osmosis Unit, a critical salt and impurity removal stage. An Energy Recovery Device (ERD) system optimizes energy usage by harvesting energy stored in high-pressure reject water from the RO membrane, and a Booster Pump elevates permeate pressure before a secondary passes through the RO unit. The desalinated water is stored in a dedicated tank for distribution.

This project aims to optimize the design and performance of the desalination system, balancing efficiency, energy consumption, and freshwater output to meet the daily target of 40m^3 while ensuring economic viability and environmental sustainability.

The system will be specifically tailored for deployment in the challenging conditions of the Arabian Gulf. This report describes the design procedure of the desalination unit, along with the methodology, calculations, and results obtained to assemble and test the system design.

Capstone Advisor

Raed Hashaikeh, Professor of Mechanical Engineering

Wave Energy Capture and Storage

Valentina Juarez Ortiz (MechE), Hugo Fan (MechE), Saleh Al Hashimi (MechE) and AbdulRahman Alzaabi (MechE)

This work deals with the extraction and storage of energy harnessed from ocean waves, to be used in a self-powered reverse-osmosis (RO) desalination in conjunction with a secondary solar energy capture system to provide a consistent supply of freshwater for small coastal communities.

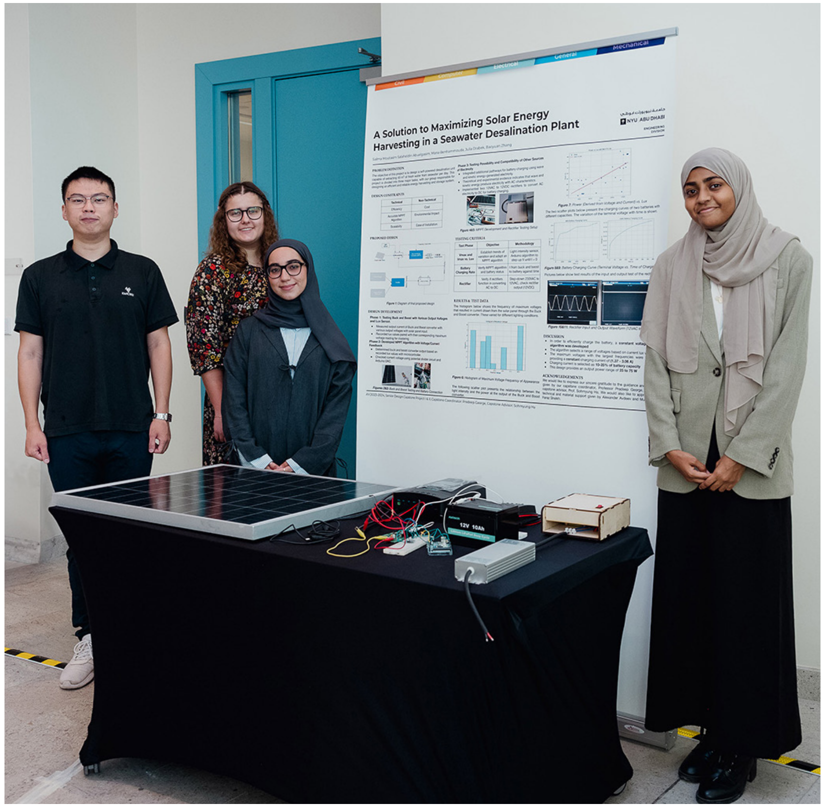
The harnessing of wave energy is facilitated by an oscillating wave chamber (OWC), which consists of a controlled capture of displaced air caused by wave oscillations, which is then converted to usable power through a power takeoff system (PTO) consisting of a Wells Turbine and induction generator.

OWCs provide a consistent source of waste-free energy, commonly integrated into on-shore breakwater systems, which allow for accessibility of functional components without the risk of damage from naturally occurring waves.

Capstone Advisor

Mohammed Farid Daqaq, Professor of Mechanical Engineering

A Self-Powered Desalination Unit with Dual Modes of Operation: Solar Power Capture



Salma Moutasim Salaheldin Abuelgasim (ElecE), Maria Benhammouda (ElecE), Julia Drabek (ElecE) and Baoyuan Zhang (ElecE)

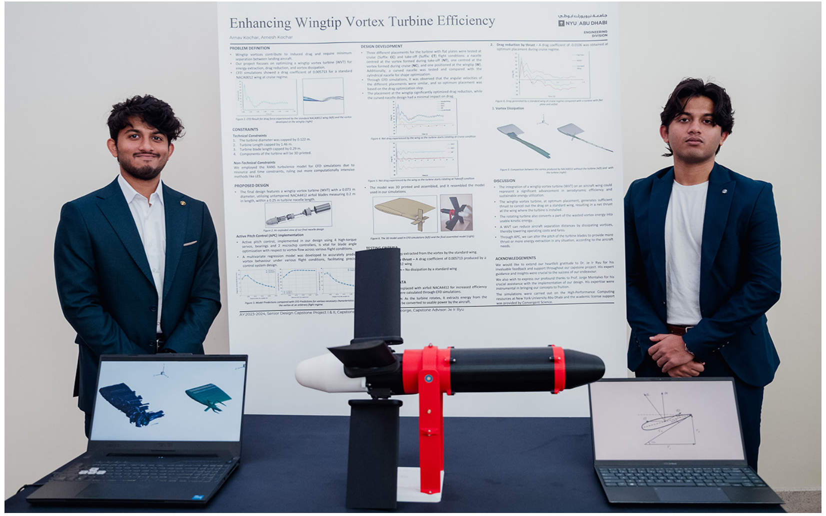
In this project, we introduce a capstone project of designing a self-powered desalination unit. Our objective is to design a scalable desalination unit, powered by two modes of energy, solar and wave, which can generate necessary pressure to pump saline water through a reverse osmosis (RO) membrane and produce required daily fresh water supply. The main goal of the project is to sustainably generate fresh water for coastal communities that do not have access to fresh water. The two operation modes, combined or separately, are to sustain a small community of 200 individuals by providing 40*m*3 of fresh water per day.

Our primary focus lies in designing and testing the solar energy mode, which includes the management of charging and discharging a battery responsible for powering the desalination unit. The proposal outlines our problem analysis, classification, and problem statement. We also acknowledge the constraints and criteria for evaluating and testing the design, and we present our project deliverables. Following a review of the necessary research background, we explore three potential solutions: employing a polycrystalline solar panel with buck and boost converters and resistors to track the maximum power point (MPPT) with a lithium battery for energy storage, a monocrystalline solar array with MPPT tracking and a lithium-ion battery, or a monocrystalline solar panel with a PWM converter and lithium-ion battery. These three design options will undergo testing and evaluation to determine the most optimal solution.

Capstone Advisor

Sohmyung Ha, Assistant Professor of Electrical Engineering & Bioengineering

Enhancing Wingtip Vortex Turbine efficiency through drag minimization and optimal placement



Arnav Kochar (MechE) and Arnesh Kochar (MechE)

Optimizing aircraft design hinges predominantly on the reduction of drag, a paramount factor influenced by elements such as flow interference, skin friction, and induced drag. Flow interference and skin friction, stemming from variables like aircraft geometry and surface smoothness, contribute to the former, while induced drag is contingent upon the lift generated by the aircraft. This dependency on lift introduces variability in induced drag, as it is influenced by factors affecting the lift coefficient under specific flight conditions. In typical transport aircraft, induced drag typically constitutes approximately 10 to 15 percent of the total drag during cruise conditions and rises to 35 to 40 percent at higher lift coefficients.

Wingtip vortices are a common feature of aircraft operation and significantly contribute to induced drag. These rotational air currents, generated at the wingtips during lift production, consume a considerable amount of energy, thereby diminishing fuel efficiency and exacerbating the pressure differential. Along with slowing the aircraft down, the persistence of wingtip vortices enforces a minimum separation distance to be maintained between landing aircraft. This separation is imperative for safety reasons,

as encountering these vortices has the potential to induce turbulence and instability in trailing aircraft. The need for such separation, however, results in heightened air traffic control measures and potentially longer wait times for landing aircraft, thereby presenting cost implications for airlines and passengers alike.

Many wingtip devices have been investigated to mitigate the challenges associated with wingtip vortices. One such wingtip device is the wingtip vortex turbine (WVT) which disrupts the flow of this vortex, reducing the wake while extracting the rotational energy of the vortex. Thus, a series of applications for the turbine have been hypothesized, such as powering avionics, flight control systems, etc.
To increase the efficiency of the WVT, research needs to be conducted on the optimum placement of the nacelle of the turbine. Ideally, the WVT should be placed such that its nacelle matches the centerline of the produced vortex. This condition is difficult to achieve under different stages of flight because the vortex centerline shifts with different angles of attack (AOA) and aircraft velocity.

Thus, the optimum position of the nacelle is different for different stages of flight and a compromise must be reached if a stationary nacelle is used for the WVT. Furthermore, it is important that the addition of these turbines leads to the least amount of drag increment as compared to the standard wing. Therefore, in the present study, the wingtip vortex turbine (WVT) was investigated with the objectives of nacelle placement and drag optimization.

Capstone Advisor

Je Ir Ryu, Assistant Professor of Mechanical Engineering

Bioengineered Small Diameter Vascular Grafts (SDVG) to Address Unmet Clinical Needs

Rashik Chand (BioE), Julio Zuazola (MechE), and Seung-Jean Kang (BioE)

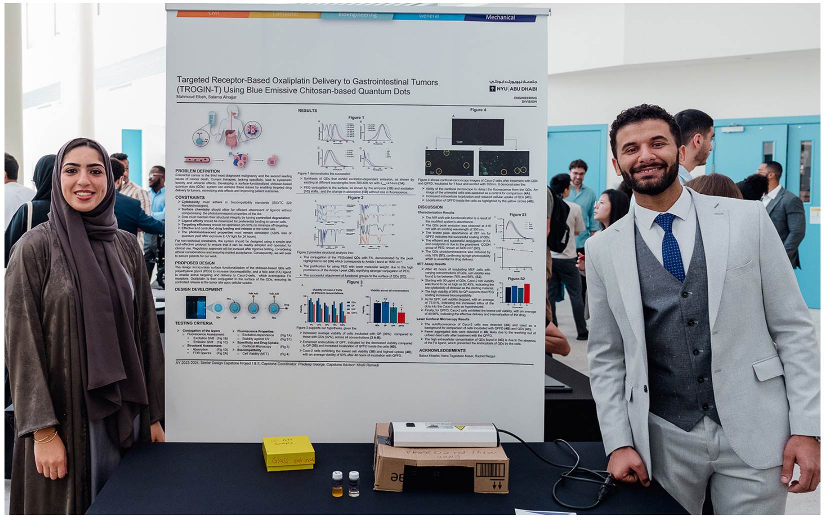
Artificial grafts are prosthetic tubes created to replace or divert flow from obstructed arteries. The golden standard of those vascular grafts is autologous tissue, normally extracted from the intrathoracic arteries (ITA) or saphenous vein. While artificial vascular grafts have been commercially available for large sizes, the engineering of grafts with diameters smaller than 6 mm remains elusive. The small size and synthetic polymers promote intimal hyperplasia, which in turn causes thrombosis and rupture if the graft is not replaced surgically, creating a larger risk of complications for the patients.

This work aims to test different designs of small-diameter grafts by combining physical material tests and simulation to find viable options. This work mainly focuses on the mechanical properties of biocompatible polymers to select the most promising dimensioning, geometry, and manufacturing processes. Diameters from 1 to 6 mm will be considered, and different possible designs will be compared.

Capstone Advisor

Vijayavenkataraman Sanjairaj, Assistant Professor of Mechanical Engineering and Bioengineering

Targeted Receptor-based Irinotecan and Oxaliplatin Delivery to GastroIntestinal Tumors (TRI-GIT)



Mahmoud Elbeh (BioE) and Salama Alnajjar (BioE)

Gastrointestinal (GI) cancer remains a major health concern with traditional treatment modalities failing to address inherent challenges such as lack of specificity, systemic toxicity, and drug resistance. Therefore, we seek to design a platform to address the problem of off-targeted and non localized drug delivery to GI tumors by creating a targeted delivery system to cancer cell sites.

In this study, we propose an innovative folate-ligand functionalized chitosan-based quantum dot system for targeted drug delivery to GI tumors, more specifically, colorectal tumors. Capitalizing on the biocompatible nature of chitosan, these quantum dots mitigate the cytotoxic risks associated with conventional heavy metal-based nanoparticles used in cancer drug delivery. The folate-ligand functionalization, ensures precision targeting and transcytosis across the intestinal barrier, effectively delivering therapeutic agents to the target site.

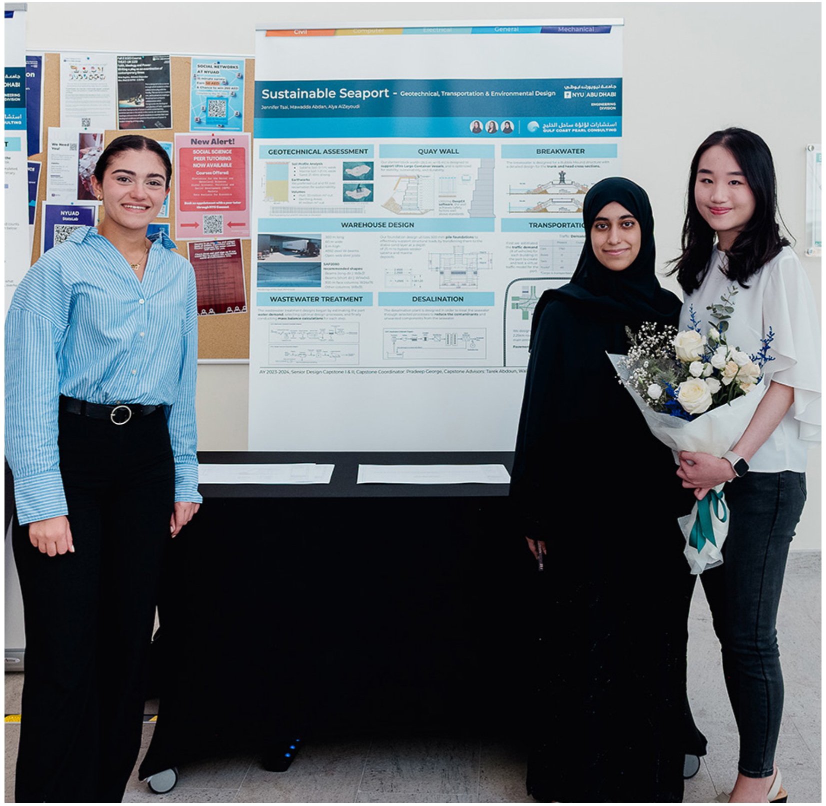
Notably, the anti-cancer drug, oxaliplatin and/or irinotecan, is loaded onto the nanoparticle and is then released intracellularly, bypassing efflux pumps, a common cause of chemotherapy failure, and potentially overcoming drug resistance mechanisms. In addition to this, the fluorescent properties of the quantum dots will help track the location of the nanoparticle with respect to the cells and confirm if the drug reached the target site and was successfully uptaken by the cancer cells when imaged.

This approach combines the benefits of targeted drug delivery and controlled intracellular release, offering a promising therapeutic strategy for GI cancers. In-vitro testing on Caco-2 cell lines will elucidate the potential of this novel drug delivery system in enhancing treatment efficacy while minimizing systemic side effects.

Capstone Advisor

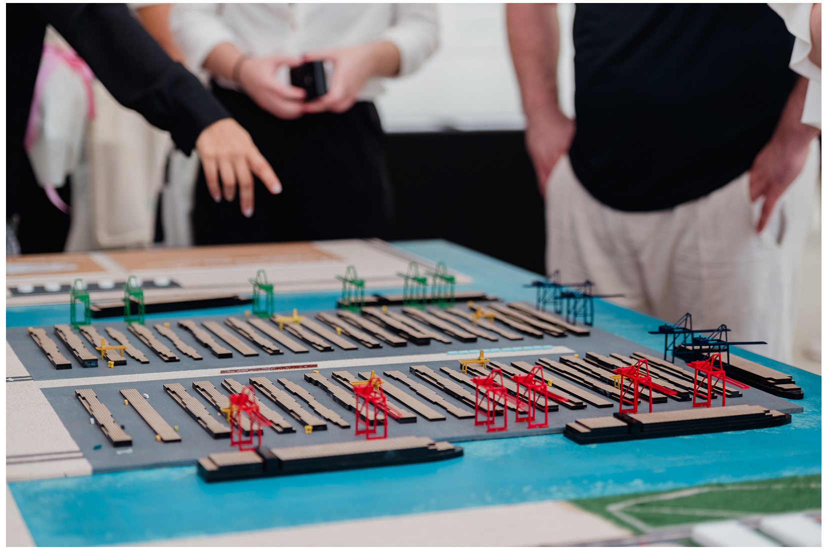
Khalil Ramadi, Assistant Professor of Bioengineering

Design and Sustainability solutions for a Sea Port | Port Introduction, Transportation, Water Treatment & Sustainable Measures



Alya Al Zeyoudi (CivE), Jennifer Tsai (CivE) and Mayher Matharu (CivE)

The seaport industry holds a crucial role in global economies and international trade, especially for diversifying economies like the United Arab Emirates. However, conventional seaport layouts often prove inefficient, leading to heightened energy consumption, pollution, and adverse environmental consequences. There is a clear need for sustainable seaport designs as the world grapples with the impacts of climate change and an increasing demand for eco-friendly solutions.



This urgency is particularly pronounced in the UAE, given its limited freshwater resources and coastal location. This project aims to conceptualize and assess a sustainable seaport in the UAE, emphasizing aspects such as structural/geotechnical elements, transportation, and water treatment/desalination.

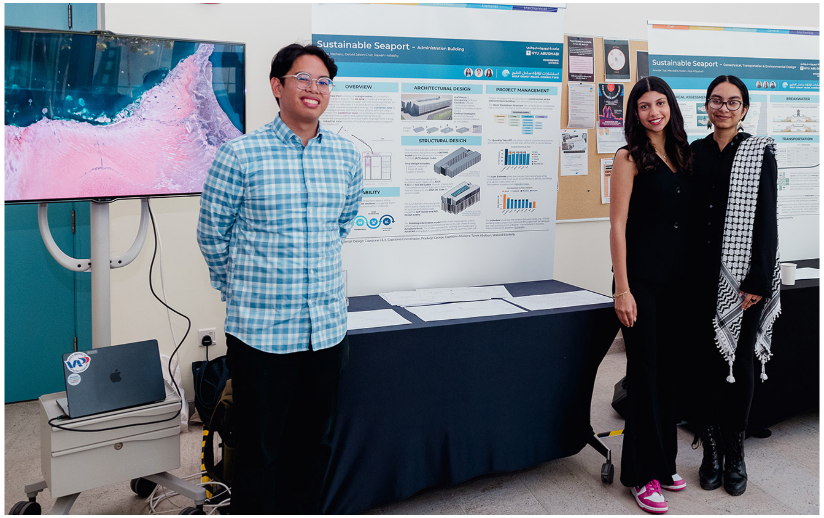
The proposed seaport will be situated on a fictional island located in the western region of Abu Dhabi. It will be connected to the mainland by way of a bridge that holds road and rail infrastructure, but will otherwise be fully isolated from mainland utilities.

Capstone Advisor

Tarek Abdoun, Professor of Civil and Urban Engineering


CLASS OF
2024

Design and Sustainability solutions for a Sea Port | Geotechnical, Foundations, Steel and Architectural



Jason Cruz (CivE), Mawadda Abdan (CivE) and Rawan Habashy (CivE)

Amidst the United Arab Emirates' strategic initiatives to diversify its economy, the development of efficient and eco-friendly seaports is critical, especially given their integral role in global commerce. Traditional port configurations typically exacerbate operational inefficiencies,contributing to increased energy consumption and pollution. As climate change continues to pose significant challenges globally, the demand for sustainable seaport designs becomes ever more pressing. In the UAE, this need is especially critical due to its limited freshwater supplies and its geographical positioning along the coast.

This capstone project proposes the design and evaluation of "Golden Dhow Seaport," a cutting-edge port located on a small island off the western coast of Abu Dhabi. The port is designed to function independently of mainland infrastructure, connected solely by a dedicated transportation bridge.

This report presents an exhaustive geotechnical, environmental, and transportation assessment and design for the "Golden Dhow Seaport." It examines the soil characteristics of the site, designs robust structures for quay walls and breakwaters, and devises steel and foundational systems for the warehouses.

The report also presents a comprehensive transportation plan, including assessments of traffic demand, signalization strategies, road layout, and pavement design. Environmental strategies are discussed throughout the report with a dedicated section focusing on innovative wastewater treatment and desalination techniques to promote sustainable practices. Each component of the project adheres to local and international building codes, incorporates findings from extensive literature reviews, and applies rigorous testing and benchmarking procedures to ensure that Golden Dhow Seaport sets a benchmark in sustainable seaport infrastructure development.

Capstone Advisor

Tarek Abdoun, Professor of Civil and Urban Engineering

Design, Implementation, and Control of an Amphibious Submersible Vehicle

Guglielmo Fonda (MechE), Seyed Ali Madani (MechE) and Akram Khairi (MechE)

The objective of this project is to design a tethered Remotely Operated underwater Vehicle that can move not only in water but also on the ground using a set of omnidirectional wheels. The ROV should be capable of diving up to 10 meters and have a velocity of 0.5 knots. The length of the fantom tether will be up to 150 meters and will carry a small gripper capable of lifting 1Kg. The ROV will deploy a floating GPS-antenna and will be capable of locating itself within the sea-current within 1x1x1m.

This ROV will be used for monitoring the coral reefs in UAE and will participate in the research efforts of the Center for Artificial Intelligence and Robotics and the Arabian Center for Climate and Environmental Sciences. The ROV will be capable of moving in ground soil using four wheels and a set of transmissions.

This project combines the efforts of mechanical, computer, and electrical engineering students. Some electrical tasks include interfacing all sensors using Robot Operating System to an ROV-computer running Ubuntu, providing a collision-free path while navigating in coral reefs, designing controllers (having human-in-the-loop) for getting close to the coral reef, and designing controllers for the omni wheel system using commercial autopilots (ArduRover).

Capstone Advisors

Anthony Tzes, Professor of Electrical Engineering and Konstantinos Kyriakopoulos, Professor of Electrical Engineering

Gross Path Planning for the Design, Implementation and Control of an Amphibious Submersible Vehicle

Malak Mansour (ElecE), Niraj Pudasaini (ElecE) and Kirubel Solomon Tesfaye (ElecE)

This project focuses on the navigation capabilities of the ROV for autonomous navigation when it is not under direct user control.

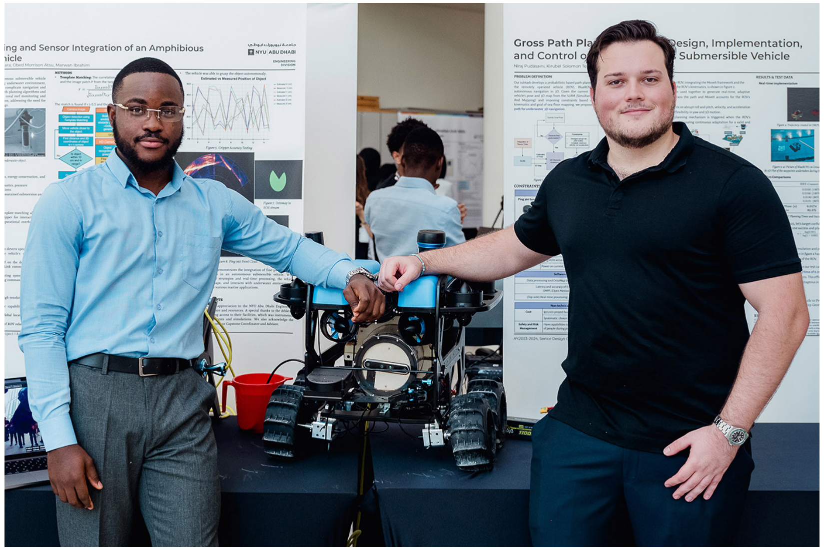
To achieve this, the ROV will utilize sensory information, specifically from sonar-based sensors, in conjunction with SLAM (Simultaneous Localization And Mapping) estimated 3D/2D map.

The primary objective is to formulate a collision-free path in the 3D/2D environment, considering the vehicle's kinematics.

Capstone Advisors

Anthony Tzes, Professor of Electrical Engineering and Konstantinos Kyriakopoulos, Professor of Electrical Engineering

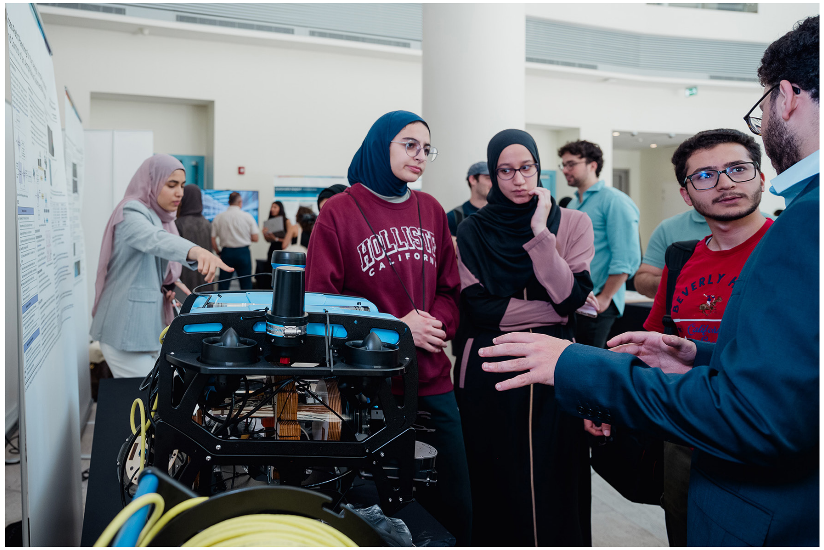
Design, Implementation, and Control of an Amphibious Submersible Vehicle: Fine Path Planning and Sensors



Argyrios Panousopoulos (ElecE), Sushil Bohara (ElecE), Marwan Ibrahim (ElecE) and Obed Morrison Atsu (ElecE)

Fine Path Planning: This project integrates computer vision and navigation controls to enable an underwater ROV to autonomously locate and grasp objects. The approach is to utilize algorithm like YOLOv3 to recognize and pinpoint target objects from live camera feeds. This allows the ROV to intelligently navigate towards objects of interest. As the ROV approaches close enough to manipulate the target, we blend in manual controls. This allows a human operator to take over and dexterously control the robotic gripper when precision maneuvering is required. By combining autonomous recognition and navigation with human judgement in the critical final phase, the system aims to robustly grasp retrieved objects. This approach is validated in a realistic MATLAB simulation environment.

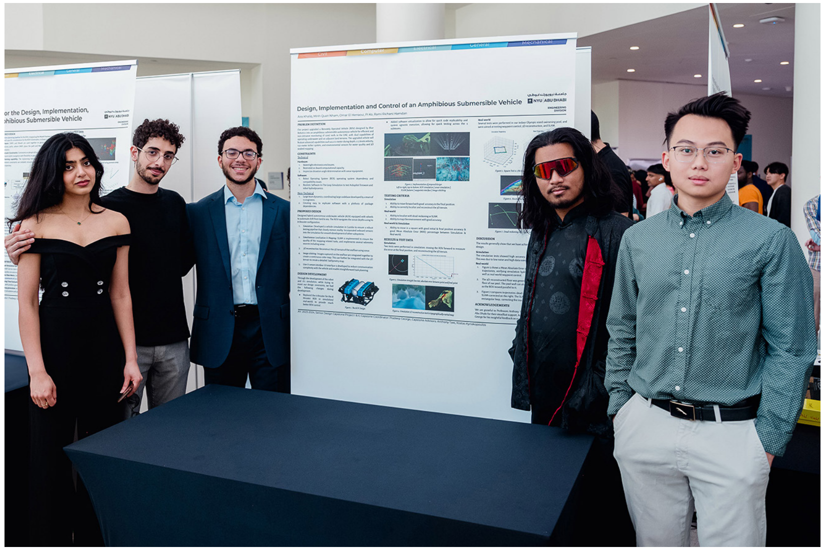
Sensors: Our task forms the cornerstone of all detection and location tracking operations, achieved through an integrated array of sensors, Doppler Velocity Logs (DVLs), and Ultra-Short Baseline (USBL) systems. This comprehensive suite includes advanced sonar technologies such as Multi-Beam Echo Sounders (MBES), line and 2D Sonars, and Mechanical Scanning Sonars, each contributing to a robust Sound Navigation and Ranging (SONAR) capability. Additionally, we incorporate a DVL to ensure precise stabilization against varying water currents, enhancing the ROV's operational accuracy. Complementing this, our USBL system is pivotal in accurately determining the ROV's underwater position. Furthermore, we have integrated pressure and leak sensors into our system to promptly identify any undesired leaks, ensuring the integrity and safety of our operations. To aid in close-quarter object detection, a high-definition (HD) camera has been included, providing clear and detailed visual feedback, essential for fine object detection.



Capstone Advisors

Anthony Tzes, Professor of Electrical Engineering and Konstantinos Kyriakopoulos, Professor of Electrical Engineering

Design, Implementation and Control of an Amphibious Submersible Vehicle



Aira Khaliq (CompE), Minh Quan Nham (CompE), Omar El Herraoui (CompE), Pi Ko (CompE) and Rami Richani Hamdan (CompE)

In this capstone project, we intend to develop a Remotely Operated Vehicle (ROV) capable of functioning both underwater and on land. Equipped with omnidirectional wheels, this versatile ROV can dive to depths of 10 meters and travel at 0.5 knots.

Specifically designed to monitor coral reefs in the UAE, it offers 3D-SLAM imaging of the seafloor and features a manipulator for object retrieval. To ensure precise location tracking amidst strong sea currents, the ROV includes a floating GPS antenna.

We plan to enhance an existing ROV model by integrating sonars, RGB-D cameras, and sensors to monitor water quality indicators such as dissolved oxygen, salinity, pH, and temperature.

To further its navigational capabilities, a floating GNSS device will be used. Safety features are incorporated to prevent underwater collisions during detailed imaging. The engineering behind this ROV encompasses electrical, mechanical, and computer domains.

The testing phase will commence in the water tanks of New York University Abu Dhabi, followed by real-world tests in the UAE's coral reefs.

Capstone Advisors

Anthony Tzes, Professor of Electrical Engineering and Konstantinos Kyriakopoulos, Professor of Electrical Engineering

Design of Low Cost NeoNatal Incubator

Mariam Aldhaheri (BioE), Thabiso Percy Xaba (BioE), Shaikha Alshehhi (BioE), Maksat Khobdabayev (BioE) and Aman Assali (BioE)

Ethiopia stood on the 5th rank among countries with the highest number of neonatal deaths in the world, with 33 deaths per 1000 live births as of 2019, due to limited access to appropriate medical equipment.

This capstone project specifically targets this challenge by designing and developing a cost-effective neonatal incubator for preterm and low birth weight infants, who are among the most vulnerable.

The proposed incubator, designed with cost-effectiveness and local resource availability in mind, incorporates a structural support system, an insulated enclosure, a temperature-controlled shell, and a secure bed for the infant. It leverages an Arduino microcontroller for precise temperature and humidity regulation, ensuring a stable and safe environment crucial for preterm infant care.

The design parameters include a length of 80 cm, height of 30 cm, and width of 30 cm, with material thickness of 5 mm, maintaining a balance between space efficiency and functionality, while keeping manufacturing costs under 1000 AED.

One of the key innovations of our design is the integration of the control unit within the incubator, optimizing space usage while ensuring isolation from the infant's compartment. This unit houses the heat exchanger and electrical components, critical for the incubator's operation. The entire design is tailored for ease of assembly and maintenance, using materials readily available in Ethiopia.

Our project not only provides the technical manual for the incubator but also commits to open-source distribution, empowering local communities to build and maintain these life-saving devices. By combining affordability, local resource utilization, and user-friendly design, our incubator stands to make a substantial impact on neonatal mortality rates in Ethiopia, offering a sustainable and replicable model for other LMICs facing similar challenges.

Capstone Advisors

Yong-Ak Song, Associate Professor of Mechanical Engineering & Bioengineering and Azhar Zam, Associate Professor of Bioengineering

Low Cost Neonatal Incubator for Developing Regions

Eshaan Patel (BioE), Fatma Alrebh (BioE), Magdalena Bak (BioE), Mauricio Lamoyi Ruiz (BioE) and Zuzanna Bak (BioE)

An estimated 340 babies die every hour in their first week of birth, with ninety-nine percent of those deaths occurring in low- and middle-income countries.

The core issue is the lack of access to electricity, impeding the availability of essential medical equipment, particularly neonatal incubators.

This disproportionately impacts premature neonates, contributing to the 2.5 million annual deaths in the first month of life, which, one again, occur primarily in low-income countries. Existing solutions lack crucial features for optimal care in resource-constrained settings, including low-cost and monitoring of vital signs.

This research aims to propose an innovative, low-cost neonatal incubator to bridge the gap in neonatal care and mitigate the impact of hypothermia on premature infants in resource-constrained settings.

By utilizing low-cost yet high-efficiency components, including polycarbonate, 12 V computer fans, and a renewable solar power source, the proposed incubator design is both user-friendly and efficient.

Capstone Advisors

Azhar Zam, Associate Professor of Bioengineering and
Yong-Ak Song, Associate Professor of Mechanical Engineering & Bioengineering

An Automated Optimization Framework for Fast and Energy-Efficient Inference of Multimodal Large Language Models (MLLMs) Targeting Embedded Devices | Group A

Ahmed Elsaid (CompE) and Omar Elkammah (CompE)

This project's main goal is to optimize a large language model, namely miniGPT, for agricultural applications. After specializing the LLM to answer specific agriculture questions, we hope to equip the LLM with another modality of interacting with it.

Specifically, we are planning on adding image moda lity to the LLM, and making it answer images about crops or pieces of land.

Our project encompasses an extensive research phase, where we evaluate the model's performance as it is right now versus the performance of other wellknown LLMs (e.g chatGPT). This evaluation is will not be only theoretical; it involves practical experimentation to understand the current model's performance answering questions related to agriculture.

We will consider factors such as response time, specificity when answering questions, and general knowledge answering about agriculture related questions. After we finish the research phase, we will shift towards fine-tuning our model to make it much better at our selected task. This will involve developing a customized version of the model, optimized for efficiency and efficacy in conversing about agricultural related topics. The goal is to create a solution that not only integrates seamlessly with existing systems but also significantly enhances data processing, analysis capabilities, and overall decision-making processes in agricultural settings. The outcome of our project is expected to set a new benchmark in the application of AI in an agricultural context, demonstrating the practical feasibility and transformative potential of advanced language models.

Capstone Advisor

Muhammad Shafique, Professor of Computer Engineering

An Automated Optimization Framework for Fast and Energy-Efficient Inference of Multimodal Large Language Models (MLLMs) Targeting Embedded Devices | Group B

Aya El Mir (CompE) and Lukelo Luoga (CompE)

In the realm of artificial intelligence, General-purpose Multimodal Large Language Models (MLLMs) like Kosmos-1 and Pangu-Sigma are redefining the capabilities of intelligent robotic systems, excelling in autonomous tasks ranging from motion planning and object sorting to VQEs and human assistance functions. Yet, their immense computational demands and expansive memory requirements present substantial barriers, causing inference costs and challenging their integration into embedded systems.

Current approaches to solving this problem, such as computational offloading, offer only temporary relief, underscoring the need for sustainable low-power deployments on embedded GPUs. This capstone project is to design an automated optimization framework for reducing the computational complexity and memory footprint of MLLMs to enable their fast and energy-efficient inference on embedded devices such as Nvidia Jetson Xavier/Orin.

Our approach investigates a spectrum of optimization techniques, such as efficient architecture search, pruning, quantization, layer skipping, and spatial-temporal sub-sampling, assessing their impact on performance, energy efficiency, and memory usage. The goal is to pinpoint the set of most effective (Pareto-optimal) optimizations that offer a significant reduction in the resource consumption of MLLMs without impacting their accuracy, and then design an automated optimization framework that systematically combines the identified optimization techniques to achieve ultra-high efficiency gains with minimal loss in accuracy. This optimized framework will culminate in its application to a real-world robotic prototype, equipped with diverse sensors for multifaceted tasks.

Capstone Advisor

Muhammad Shafique, Professor of Computer Engineering

An Automated Optimization Framework for Fast and Energy-Efficient Inference of Multimodal Large Language Models (MLLMs) Targeting Embedded Devices | Group C

Ahmad Fraij (CompE), Flavia Trotolo (CompE) and Karim Diab (CompE)

General-purpose Multimodal Large Language Models (MLLMs) have revolutionized our day-to-day life and are implemented in many fields for the purpose of animation of embedded tasks such as motion planning, object sorting, and assistance in daily human tasks.

In the realm of artificial intelligence, the capabilities of Multimodal Large Language Models (MLLMs) are transformative, yet their implementation within embedded systems is hampered by high computational loads and extensive memory usage, which in turn inflate the costs associated with inference.

Addressing this, the capstone project centers on developing an automated optimization framework aimed at diminishing the computational complexity and shrinking the memory footprint of MLLMs. The framework aspires to refine these models for effective incorporation into the compact and power-sensitive domain of embedded systems, which are becoming increasingly ubiquitous in the arena of smart technology and IoT. The strategic compression of these models is imperative, enabling embedded systems to harness the intelligence of MLLMs for autonomous, real-time decision-making critical in applications with stringent latency, privacy, and independence requirements, such as in medical devices, automotive safety features, and environmental monitoring.

This breakthrough in LLM compression promises to elevate the operational efficiency and extend the applicability of embedded systems, thereby catalyzing progress and innovation in multiple sectors where embedded artificial intelligence is projected to have a significant impact.

Capstone Advisor

Muhammad Shafique, Professor of Computer Engineering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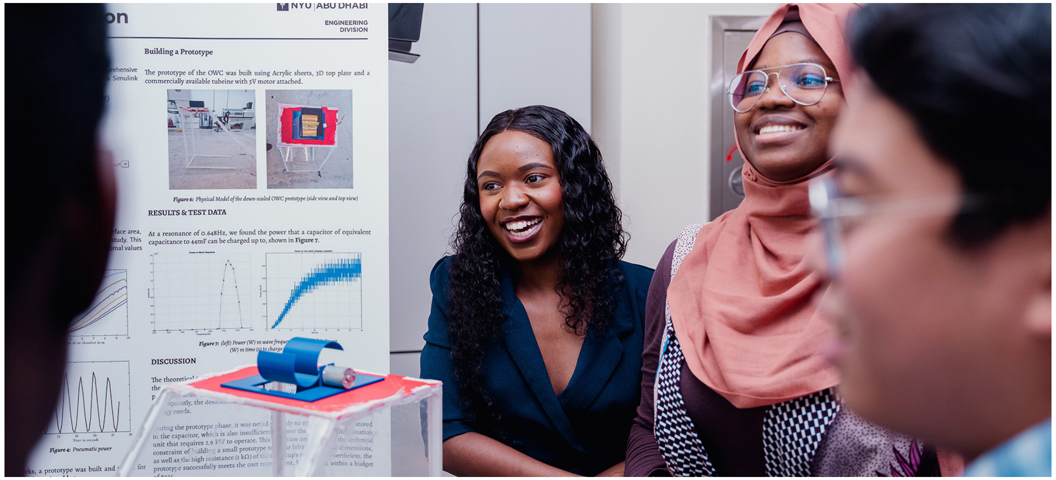
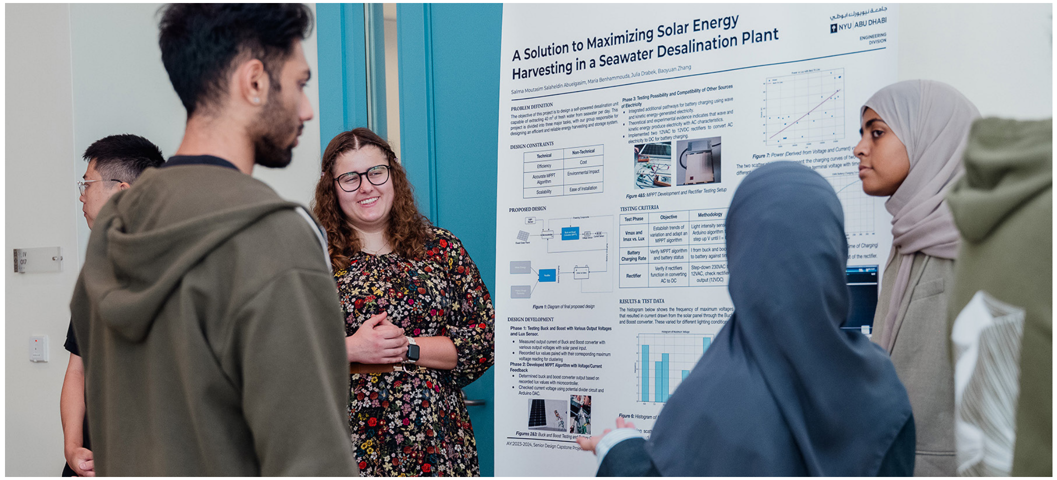

NYU ABU DHABI
ENGINEERING DIVISION
Building a Prototype
RESULTS & TEST DATA
DISCUSSION


2018


Alarms and Indicators:
Temperature Control:
Humidity Control:
Safety Features:
Non-technical constraints:
PROPOSED DESIGN
DESIGN DEVELOPMENT


A Self-Powered Desalination Unit With Dual Modes of Operation


A Solution to Maximizing Solar Energy Harvesting in a Seawater Desalination Plant
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Desalination Unit
Pilot
Tank
Pump
DESIGN DEVELOPMENT
CONSTRAINTS


PROPOSED DESIGN
DESIGN DEVELOPMENT
TESTING CRITERIA
RESULTS & TEST DATA


Passenger Terminal


Seawater Desalination Plant
GUESS
JEANS


Low-Cost Neonatal Incubator for


Sustainable Seaport

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