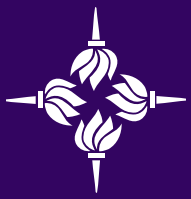

2023

ENGINEERING **CAPSTONES**

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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 2022-23.

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 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 20 projects presented by the Class of 2023 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 2023, you made it! This is 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 for 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 (CE), Mechanical Engineering (ME), Electrical Engineering (EE), Computer Engineering (CompE), Bioengineering (BioEng) and General Engineering (GE) - is in developing engineers to solve such real world problems. The capstone coordinator, Pradeep George, has designed a unique, cross-disciplinary capstone experience for the senior engineering students at New York University Abu Dhabi (NYUAD). This is different from the traditional capstone courses found in most of the global engineering offerings which focus on fulfilling the degree requirements for a specific engineering program/major.

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 capstone experience aims at solving a cross-disciplinary challenge for a team of seniors drawn from each of these programs/majors. 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 Capstone Project aims to be collaborative and cross-disciplinary across several engineering

streams. 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. There is a mid-semester review of the projects. 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 51 senior students in 19 interdisciplinary capstone projects. The titles of the projects are listed below:

1. **Smart Physical Health Screening Kiosk**
   Majors: Computer Engineering and Electrical Engineering
2. **3D printed scaffolds with varying micro-topography for the study of immunogenicity**
   Majors: Mechanical Engineering and Bioengineering
3. **A Portable Off-Grid Solution for Arsenic Contaminated Water Supplies**
   Major: Mechanical Engineering and Civil Engineering
4. **Designing an Energy-Efficient Embedded Deep Learning-SLAM for Unmanned Ground Vehicles**
   Majors: Electrical Engineering and Computer Engineering
5. **Development of a Hybrid Drone/Vessel/Vehicle**
   Majors: Mechanical Engineering, Electrical Engineering and Computer Engineering
6. **Design of Artificial Intelligence (AI) Powered Event-Based Slip detection and suppression approach in robotic grasping and manipulation**
   Major: Computer Engineering
7. **Optimized Design of Crumple Zone on Vehicles**
   Major: Mechanical Engineering
8. **Silicon Photonics for Artificial Intelligence**
   Major: Computer Engineering and Electrical Engineering
9. **Prefabricated Modular Pedestrian Bridges for Emergency Deployment**
   Major: Civil Engineering
10. **Portable Desalination Unit**
    Major: Mechanical Engineering
11. **Compression Ring Anastomosis with Electrical Stimulation to Improve Healing and Reduce Rates of Intestinal Anastomotic Leakage after Colorectal Resection Surgery**
    Majors: Bioengineering and Mechanical Engineering
12. **Design of a Machine Learning Tool for Traffic Forecasting**
    Majors: Civil Engineering and Electrical Engineering
13. **Smart laparoscopic tools for minimally-invasive surgery**
    Majors: Mechanical Engineering
14. **Smart Health Tracking Device to Support Assessment of Breast Cancer Prognosis**
    Majors: Computer Engineering
15. **Home-Based XR Upper Limb Rehabilitation System for Post-Stroke Patients using Vibrotactile Feedback**
    Majors: Computer Engineering and Electrical Engineering
16. **Bioprinting of Biomimetic Meniscal Tissue**
    Majors: Bioengineering and Mechanical Engineering
17. **Parametric Study of Tesla Valve in a MEMS Drug Delivery System**
    Majors: Mechanical Engineering
18. **Simple, Resilient and Low Cost Aeroponics System for Use in Developing Countrie**
    Majors: Mechanical Engineering and Civil Engineering
19. **Design of cryopreserved paper-based slips of cell lines and tumor models for commercial use**
    Majors: General Engineering

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
Senior Lecturer and Coordinator of Engineering Capstones
NYU Abu Dhabi

CAPSTONE PROJECTS

Smart Physical Health Screening Kiosk

Muhammad Areeb Ashar (CompE) and Rameen Mahmood (EE)

The experience of a patient visiting the doctor is a multistep process that involves registration at the hospital, a physical check-up of a patient's vitals, and a consultation with a physician. Amongst all of these steps, the most unpleasant part of the process was shown to be the prolonged waiting times. According to the pre-kiosk market survey we conducted of 24 NYU Abu Dhabi students, 82% of participants wished to have reduced waiting times during their visit to the clinic.

Our project, the Smart Physical Health Screening Kiosk, aims to minimize the extended waiting times by automating the process of physical examination of a patient's vitals and providing the user with a preview of the possible ailments they may be afflicted with. The proposed solution uses a hardware setup of a microcontroller (Raspberry Pi), physical sensors, and a touch-friendly kiosk so that users can measure their vital signs and record their symptoms. We expect to demonstrate through the proposed system a reduced time consumption which results in a more pleasant experience compared to the multi-step process of a patient consultation with the doctor.

Capstone Advisor

Tuka Waddah Alhanai, Assistant Professor of Computer Engineering

3D Printed Scaffolds with Varying Micro-topography for the Study of Immunogenicity

Ibrahim Nayfeh (ME), Brian Chesney Quartey (BioEng) and Budoor Alyousuf (BioEng)

Implantation of biomaterials to facilitate tissue repair and regeneration or replace damaged tissue has become an important part of medicine. Such implants for replacing damaged tissue include heart valves, stents, artificial joints, ligaments, dental implants, and many others. In cases of wounds that do not properly heal due to chronic inflammation for various reasons, biomaterial scaffolds may be used to provide necessary structural support for cells to grow, proliferate and differentiate, thus facilitating tissue regeneration and repair. An unavoidable issue that comes with the implantation of biomaterial implants has to do with the acceptance or rejection of the implant by the host's immune system.

It is known, however, that different biochemical and mechanical properties may modulate the functioning of immune cells. Hence efforts to improve acceptance of biomaterial scaffolds involve designing them, keeping in mind biomaterial properties that would promote acceptance of the implant by the host immune system. In this project, we aim to design and 3D print scaffolds with different micro-topography and investigate which patterns can better modulate the host immune system towards acceptance of biomaterial implants.

Our work will inform decisions on the design of the implant surfaces for various applications.

Capstone Advisor

Vijayavenkataraman Sanjairaj, Assistant Professor of Mechanical Engineering and Bioengineering
Jeremy Teo, Assistant Professor of Mechanical Engineering and Bioengineering

A Portable Off-Grid Solution for Arsenic Contaminated Water Supplies

Ahmed Ismaeili (ME), Ali Al Dhanhani (CE), Fizza Fatima Rana (CE) and James Jiang (CE)

The objective of this capstone project is to design a portable, cost effective, off-grid solution for the removal of arsenic from groundwater. Elevated levels of arsenic in groundwater have been reported to be a major issue in many countries. Arsenic presence, being a serious health risk, must be dealt with as the element possesses multiple toxic forms. Being exposed to Arsenic can lead to numerous types of cancers and diseases.

After carefully studying the market for the best technologies, including reverse osmosis, ion exchange, iron oxide adsorption, and sorptive filtration, the compact solution will use one or multiple solutions in order to achieve the desired levels of arsenic concentration in the treated water. The solution will be worked into a portable, compact box-like housing that can be easily operated by any household. The solution will also ensure a sufficient capacity of water for a family's daily needs, and will deal with waste management issues. The power source might vary from a hand powered pump to an automatic power source based on the desired flow rates, and the cost of each method, as this project aims to be a viable solution for the masses.

Capstone Advisor

Daniel Johnson, Assistant Professor of Civil and Urban Engineering

Designing an Energy-Efficient Embedded Deep Learning-SLAM for Unmanned Ground Vehicles

Umer Bin Liaqat (EE), Moaaz Assali (EE) and Fatema Alzaabi (CompE)

One major problem with using machine learning algorithms for autonomous robots is that they may not be optimized enough to be deployed on resource-constrained devices in terms of energy consumption and computational speed.

The proposed solution for this capstone is a hardware-aware optimization framework for embedded deep learning that can accept Deep Learning - Simultaneous Localization and Mapping (DL-SLAM) algorithms as input along with the hardware limitations and perform a number of Deep Neural Network (DNN) and algorithmic optimizations (such as pruning, quantization, data reuse, and automatic regularization). In order to enable high-throughput and energy-efficient DL-SLAM with the smallest possible power and memory footprint, the optimization framework takes into account both the hardware platform characteristics and algorithms. Additional energy and throughput gains for FPGA-based systems will be made possible by creating dedicated hardware accelerators for DL-SLAM. To account for different battery energy densities, these accelerators can be implemented in scaled computing effort modes.

The finalized DL-SLAM algorithms will be implemented on real-world Unmanned Ground Vehicle (UGV) / Rover prototypes for demonstration and thorough validation after being developed, trained, optimized, and tested.

Capstone Advisor

Muhammad Shafique, Professor of Computer Engineering

Development of a Hybrid Drone/Vessel/Vehicle

Emmanuel Fashae (ME), Dimitrios Mastrogiannis (EE) and Dimitris Chatzoulis (CompE)

The objective of this project is to develop a platform for monitoring offshore oil drilling stations and gas pipelines. The monitoring needs to be done in a relatively economical and fast way and thus the time decided to develop a hybrid Unmanned Aerial Vehicle (UAV), able to move on water, ground terrain and in the air.

The team decided that the hybrid UAV poses the best solution as it would be relatively cheap to develop, it would not require direct control by humans, and it would be able to fly to the drilling station using its drone capability, move on water using its jet thrusters, collect data, fly back to shore and move using its omni wheels from the shore to the monitoring station.

The monitoring of the pipelines will be accomplished with the hybrid UAV flying to the pipeline, moving up and down the pipeline using the omni wheels, while collecting camera footage and then flying back. The hybrid UAV is an economical and scalable solution that requires minimal human control.

Capstone Advisor

Antonios Tzes, Program Head of Electrical Engineering; Professor of Electrical Engineering

Design of Artificial Intelligence (AI) Powered Event-Based Slip detection and suppression approach in robotic grasping and manipulation

Baraa Al Jorf (CompE), Eddie Han (CompE), Manuel Padilla (CompE) and Priyanshu Mishra (CompE)

This capstone project aims to implement a fully autonomous library navigation robot that is able to assist librarians in daily library organization duties. To achieve this goal, the robot will have unsupervised operational capabilities including self-localization and pathfinding, as well as being able to interact with the environment through its 7 degrees-of-freedom arm manipulator. The robot will also utilize AI for its various subcategories, its capabilities being trained in a simulated virtual environment to accelerate its learning process.

The four major subcategories the project relies upon are; self-localization and mapping (SLAM) to be able to understand itself and the surroundings, navigation, and pathfinding to be able to move within its given environment, robot arm manipulation to perform object movement tasks necessary to achieve its goal and simulation to train and attest the operation of the robot.

Capstone Advisor

Yi Fang, Associate Professor of Electrical and Computer Engineering; Associate Professor of Computer Science (Affiliated)

Optimized Design of Crumple Zone on Vehicles

Christopher Tagle (ME), Habiba Eldababy (ME) and Kenechukwu Ezeifemeelu (ME)

High risk car crashes are a leading cause of death for all age groups across the world, making passenger safety upon high-impact collisions a critical issue to address. The crumple zone is the main absorber of energy for frontal collisions, and longitudinal beams inside the crumple zone are one of the most effective components inside the crumple zone due to their high specific energy absorption. This means that the structure absorbs a large amount of energy compared to its mass. Moreover, car emissions are a main contributor to global warming worldwide and reducing emissions through weight reduction of cars is necessary.

There is a need to produce lighter cars with the same safety performance, preferably at an affordable price. Thus, innovation of longitudinal beam design is critical to the design of efficient, lightweight, and cost-effective crumple zones.

Our goal is to investigate different loading scenarios, materials, and geometries for crumple zones with the purpose of optimizing performance, weight, and cost. The design will focus on the longitudinal beams in the crumple zones, optimizing their crash mechanism to absorb maximum energy in high-speed crash scenarios and resist deformation in low-risk bumps. The longitudinal beam designs from existing literature have proven honeycomb structures, thin-walled tubes, and foam integration effective structures for absorbing energy.

High strength metals such as steel and aluminum both provide efficient energy absorption at different properties of weight, cost, and hardness. Newer composite materials prove effective energy absorbers when compared to their weight, but the higher cost may be a barrier for use.

The criteria of optimization of the longitudinal beams in the crumple zone are good absorption of impact energy, effective passenger protection, and maintenance of light weighting and cost-effectiveness. The beams should also resist deformation in low impact bumps in order to avoid large deformation of the crumple zone when the passenger risk is low.

Industry standards from the Insurance Institute for Highway Safety (IIHS) and also the National Highway Traffic Safety Administration (NHTSA) are used to evaluate the design performance and viability. The beams will be tested via explicit dynamic simulations on ANSYS, and 3D prototypes of the baseline and optimized designs will be created to be tested experimentally and compared as well.

Capstone Advisor

Mostafa Mobashir, Assistant Professor of Civil and Urban Engineering

Silicon Photonics for Artificial Intelligence

Ghaya Alshamsi (CompE), Hamad Alameri (CompE) and Saleh Aldarmaki (EE)

Due to the advancement in optoelectronic components design on photonic integration platforms, research in photonic computing has expanded. Recent progress in the design of optoelectronic components for photonic integration platforms has led to the development of ultrafast artificial neural networks using photonic integrated circuits.

These networks have become highly sought-after in fields such as medical diagnostics, telecommunications, and high-performance computing. However, there are still issues with processor latency that researchers are trying to overcome by developing neuromorphic circuits that use photonics to process information at sub-nanosecond speeds.

This paper proposes a design for an optical neuron and 1x4 MMI waveguide that is both fast and scalable, with the potential to be used in a deep neural network for AI applications.

Capstone Advisor

Mahmoud Rasras, Associate Professor of Electrical Engineering

Prefabricated Modular Pedestrian Bridges for Emergency Deployment

Karl Khoury (CE), Ted Hondro (Civil) and Nas Gopee (CE)

Following natural disasters like floods or earthquakes, pedestrian bridges are a crucial component of disaster aid. The lightweight aspect of FRP composites as well as their impressive mechanical properties has led to significant research being made on their use in structures today and how they can be used in order to serve as disaster relief aids.

This necessitates an ongoing inquiry into new and innovative approaches to structural design, along with a number of environmental problems regarding the old construction methods. This concept intends to provide an affordable and ecologically responsible prefabricated modular pedestrian bridge for emergency deployment. Innovative building materials and leading concepts and methods are incorporated into the suggested design to ensure its sustainability and effectiveness.

A carefully thought-out design enables the seamless integration of components that facilitate simple transportation and assembly at the emergency location. Furthermore, this project will also involve a simulation of the automated deployment method in addition to a comparative analysis against a standard steel bridge with similar specifications for a particular case study.

Capstone Advisor

Khaled Shahin, Senior Lecturer of Civil and Urban Engineering; Coordinator of Engineering Assessment
Borja García de Soto, Assistant Professor of Civil and Urban Engineering

Portable Desalination Unit

Khalifa Ballaith (ME) and Mira Aljallaf (ME)

A major issue that many parts of the world are currently confronting is access to safe drinking water, especially in Africa and the Middle East. There is an increasing demand for portable and economical saltwater desalination techniques to meet this problem. The design and operation of a portable desalination machine that employs direct contact membrane distillation are thoroughly examined in this research.

Advanced computational fluid dynamics (CFD) software was used during the design phase to optimize the fluid flow and heat transfer within the membrane module and the heat exchanger. The design was iteratively refined to increase effectiveness and performance after many prototypes were constructed and tested under varying operating conditions. The finished system emphasizes mobility and power efficiency while demonstrating exceptional performance and dependability.

The report also investigates the use of renewable energy sources to power the desalination system, emphasizing the potential for sustainable and cost-effective solutions to address the global water crisis.

Capstone Advisor

Raed Hashaikeh, Professor of Mechanical Engineering

Compression Ring Anastomosis with Electrical Stimulation to Improve Healing and Reduce Rates of Intestinal Anastomotic Leakage after Colorectal Resection Surgery

Aliha Nisha (BioEng), Jesper Holter (BioEng), Parima Phowarasoontorn (ME) and Soja Rajakaruna (ME)

Colorectal resection surgery is a procedure for treating intestinal cancer where a section of the intestine is removed. In this surgery the ends of the remaining intestine are joined together to form what is known as an anastomosis. A prevalent and potentially life-threatening complication of this surgery is anastomotic leakage. The leakage is thought to be caused by excessive breakdown of collagen, slow rate of wound healing, infection from local intestinal bacteria, and patient risk factors such as a history of chemotherapy, old age, obesity and/or smoking.

Much research is dedicated to reducing the frequency and severity of leakages by improving surgical technique. Current clinical techniques include hand-sewing, stapling, and implanted compression devices.

This paper aims to build on existing research by designing a system which integrates electrical stimulation for improved wound healing with a compression ring device.

Capstone Advisor

Khalil Ramadi, Assistant Professor of Bioengineering

Design of a Machine Learning Tool for Traffic Forecasting

Fadhel Barakat (CE) and Sai Deep Sreekumar (EE)

With more than 1.4 billion vehicles worldwide, traffic congestion is a fundamental challenge that has considerable economic impact, especially in nations where part of the economy depends on transportation systems—which happens to be most nations worldwide. In the United States alone, the freight sector loses more than $74 billion annually due to congestion, and costs to individual drivers exceed $88 billion. While there are vast quantities of traffic data that can be used to monitor, assess, and improve the performance of those same transportation systems, interpretation of this data is difficult due to its abstract, unstructured, and high-dimensional nature.

To overcome this challenge, the proposed project will design and implement a data analytics tool by combining computational techniques such as network science and machine learning (specifically, the K-Nearest Neighbors (KNN) algorithm). This tool will rely on data obtained from a traffic simulator, AIMSUN, to train and test the tool, and it will observe traffic patterns and make estimations of traffic based on said patterns (both temporal and spatial predictions).

The goal is to combine human capabilities with machine intelligence to uncover fundamental driving forces underpinning traffic congestion and dissipation. The accuracy of the tool will be tested by providing limited simulation data to the tool and comparing the output to the full simulation.

Capstone Advisor

Monica Menendez, Associate Dean for Graduate Programs; Director of the Research Center for Interacting Urban Networks (CITIES); Professor of Civil and Urban Engineering
Andras Gyorgy, Assistant Professor of Electrical Engineering and Bioengineering

Smart Laparoscopic Tools for Minimally-invasive Surgery

Kojo Vandyck (ME) and Ma-sum Abdul-Hamid (ME)

Minimally Invasive Surgery (MIS) is a surgical operation that involves the operation of internal organs via small incisions (or holes) created in the patient's skin. Access to the internal organs is made possible via long tubular devices known as laparoscopic tools to either grasp or palpate, among other surgical operations. The known advantages of this approach include increased recovery speed, more aesthetically pleasing surgical outcomes, and less risk of external infections. However, this approach comes with its downsides, surgeons are limited in their ability to estimate organ or tissue stiffness since only the shaft of the laparoscope enters the body and not the surgeons' hands like in open surgeries. A lot of research has been dedicated to augmenting current or designing new laparoscopic tools capable of accurately and instantaneously measuring and providing the user with results on the material stiffness and how much force is being applied to internal organs. The significance of this research is that it gives the surgeon the third eye to be able to understand how much force is applied to organs during surgery to avoid potential injuries and effectively increase the accuracy of operations.

This project seeks to introduce a smart laparoscopic system augmented with low-cost, MEMS-based sensors to provide real-time grasping feedback to enhance the surgeon's force estimation ability ultimately enhancing the speed of operation with minimal chance of injury. In addition, this work intends to develop a more bio-compatible approach involving accurate sensors that do not need to penetrate the body. Lastly, this work promises to contribute to the field of robotic surgery as the MEMS sensors developed could be incorporated into robotic systems as more bio-compatible alternatives.

Capstone Advisor

Mohammad Qasaimeh, Associate Professor of Mechanical Engineering and Bioengineering; Engineering Faculty Diversity Liaison

Smart Health Tracking Device to Support Assessment of Breast Cancer Prognosis

Khoula Alriyami (CompE), Maya Fayed (CompE) and Shaza Elsharief (CompE)

The objective of our project is to design and model a smart health-tracking device to support the assessment of breast cancer prognosis. With the rise of breast cancer patients, the prognosis process has been stretched out due to a long waiting time between doctor visits.

With this problem occurring at an even higher level for patients who require a long trip to cancer screening centers, the issue has set back breast cancer patients from receiving a quicker treatment. Therefore, a system is required to help in the aforementioned situations, saving the patients' time and improving their treatment process.

The proposed solution is a tracking device to support the assessment of breast cancer prognosis in order to boost clinical care effectiveness. The hardware system is an at-home device that takes thermal images and natural images, combines them with the patient's medical history, and determines whether the images raise a concern that require a doctor's visit.

To complement the hardware device designed, we develop a multi-modal algorithm to aid in using multiple sources of medical data to enrich predictions.

Capstone Advisor

Farah Emad Shamout, Assistant Professor of Computer Engineering

Home-Based XR Upper Limb Rehabilitation System for Post-Stroke Patients using Vibrotactile Feedback

Yuki Li (CompE) and Nati Tsegaye (EE)

Millions of people are affected by stroke both worldwide and in the UAE. It is estimated that 13 million people would be victims of stroke every year. It is the second major cause of death and disability. Survivors go through physical therapy of varying intensities depending on the severity of the stroke they had. Rehabilitation helps stroke survivors relearn some of the lost sensorimotor functionalities or develop new ways of performing tasks to circumvent or compensate for disabilities caused when part of the brain is damaged.

The early stage of the physical therapy process aims to provide as much feedback as possible in order to give sufficient signals to the participants. Current solutions that mainly provide force feedback might not be safe for patients to use at home, the cost is generally high, and are not easily portable.

This project focuses on providing an extended reality (XR) upper limb rehabilitation system involving a virtual reality (VR) and vibrotactile feedback. It explores the potential of vibrotactile feedback in providing safe and intuitive feedback for the patients. The vibration feedback is provided using a custom built vibrotactile wristbands. Unity3d will be used to provide auditory and visual feedback in the VR simulation.

Capstone Advisor

Mohamad Eid, Associate Professor of Electrical Engineering

Bioprinting of Biomimetic Meniscal Tissue

Abhay Menon (BioEng) and Annalise Langdon (ME)

The menisci are crescent-shaped cartilaginous tissue situated in the knee which are necessary for load bearing, stress distribution and shock absorption in the knee joint. As such, they are subjected to different compressive and shear forces and consequently, meniscus injuries are common across a range of ages. However, due to the low regenerative capacity of the tissue, injuries can lead to degradation of the joint, as well as severe pain, swelling and in some cases arthritis.

Meniscal tissue engineering is a developing strategy for meniscus regeneration and knee joint preservation. With the advent of 3D bioprinting, fibro-chondrocytes present in the meniscus can be embedded in a bioink made of its natural extracellular matrix (ECM) and printed in a geometrically accurate structure that closely replicates native tissue features.

The objective of this project is to conceptualise and design the microarchitecture of biomimetic meniscal tissue and to 3D bioprint a biomimetic meniscal tissue construct which can be used as an implant to replace damaged meniscus tissue. The bioprinted meniscal tissue construct will then be tested for its mechanical and biological properties and compared to those of native human tissue.

Capstone Advisor

Vijayavenkataraman Sanjairaj, Assistant Professor of Mechanical Engineering and Bioengineering

Parametric Study of Tesla Valve in a MEMS Drug Delivery System

Aayush Karna (ME) and Seoyoung Kim (ME)

MEMS Drug Delivery System is crucial for patients suffering from chronic diseases and has significant benefits including high controllability of drug dosage. In particular, integration of the passive valve, the Tesla valve in this study, can potentially achieve high controllability of direction and timing of drug dosing, as well as prevention of the backflow of the drug.

This project proposes MEMS drug delivery system integrated with a Tesla valve and presents a performance analysis done both theoretically and experimentally. This project will discuss the simulation, modeling, and experimental testing of the proposed design. CFD modeling of the Tesla valve will be done to first optimize the design of the valve suited for MEMS application with an acceptable range of diodicity value (< 2). Followingly, the experimental model of the drug delivery device will be fabricated using Nanoscribe and PDMS molding.

Lastly, the model will be tested experimentally and the result will be used to determine the feasibility of the design based on the target values of diodicity and the flow rate. This report presents the background and problem analysis, steps taken to devise and conceptualize the final model, the experimental design and constraints, as well as work management guidelines.

Capstone Advisor

Sunil Kumar, Program Head of Mechanical Engineering; Professor of Mechanical Engineering
Je Ir Ryu, Assistant Professor of Mechanical Engineering

Simple, Resilient and Low Cost Aeroponics System for Use in Developing Countries

Patrick Dowd (ME), Beniamin Strzelecki (Civil) and Anas Zeid (ME)

Aeroponics is an agricultural technique in which plants are grown without soil by intermittently misting the roots. It is one of the most prominent sustainable alternatives to traditional farming and, in most modern applications, takes place in fully controlled environments. Although controlled environments ensure optimal conditions for efficient plant growth, the technologies used in them are too costly for many farmers in developing countries who need efficient alternatives to traditional farming to face the threats of climate change.

Therefore, we are designing an aeroponics system using low-cost construction materials to test the extent to which the root and leaf environments must be controlled to maintain plant conditions within an acceptable range. Parameters including temperature, humidity, and CO2 level will be monitored using algorithms measuring real-time data from sensors. The monitoring system will also be used to automatically control the pH and electrical conductivity of the nutrient solution supplied to the plants, detect faults in the system, and alert the user through a wireless communication protocol.

A prototype of the system will be built, and evaluated on the amount of material used, sufficient strength of the structure, thermal conductivity of material, resilience to power outages, water consumption, nutrient usage, response of monitoring system, technical knowledge required to operate the system, and total cost.

Capstone Advisor

Khaled Shahin, Senior Lecturer of Civil and Urban Engineering; Coordinator of Engineering Assessment
Michael Davis, Senior Director, Laboratories

Design of cryopreserved paper-based slips of cell lines and tumor models for commercial use

Safeeya Al-Awadhi (GE)

Cell lines are useful for a myriad of purposes in scientific research to understand the pathology of disease. Labs around the world require the use of fast, efficient, and available sourcing of cell lines; especially in the UAE where cell lines are sourced from international vendors presenting high costs, loss of time and adverse impacts on samples from transportation conditions.

The conventional system of storing cells have always been in vials like Eppendorf's, however this capstone will develop and explore the use of a novel system of paper-based cryopreservation of cell lines and tumor models using Whatmann filter papers and the design of paper slips that are small, efficient, and useful for its purposes of being widely available for researchers in the scientific community.

This novel technique of cryopreservation of cells will optimize for space, time and energy as papers can be stacked compared to conventional vials. Also, paper fibers better mimic the 3D environment of cells, allowing for cells to better form more appropriate networks helping keep the integrity of the cells.

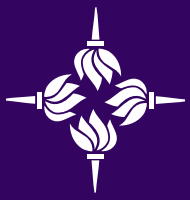
Capstone Advisor

Mohammad Qasaimeh, Associate Professor of Mechanical Engineering and Bioengineering; Engineering Faculty Diversity Liaison


CLASS OF
2023

جامعة نيويورك أبوظبي

NYU ABU DHABI



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