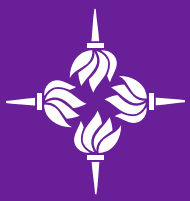
2020

ENGINEERING **CAPSTONES**



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MESSAGE FROM OUR DEAN

The Capstone Design Course provides a major design experience leveraging the knowledge and skills acquired throughout the four-year curriculum. Structured to immerse students in the process of design, projects address engineering and technology topics and design innovative solutions following the examination of multiple project parameters. The Capstone also provides students with an opportunity to integrate technical, human, aesthetic and business concerns with applied design solutions.

The Class of 2020 Engineering Capstones are based on the culmination of ideas from their Junior year and hard work throughout 2019-20 using design solutions to solve real world problems. This year however, due to the Covid-19 pandemic, our seniors had to deal first hand with this, their very own real world problem. A crisis can offer the opportunity to innovate and re-invent and as such, our students changed the scope of their projects through great capacity and resilience and for this we commend them.

The Capstone, a defining feature of the Engineering undergraduate experience, represents the highest aspirations of undergraduate intellectual development, creativity, and engagement with original creative work. In aligning with today's Engineering advances as well as our institutional research priorities, this year's Capstones include:

Collaboratively and interdisciplinary, our students developed a working prototype of a **Quad-Turbine Hoverboard**; and further developed a low cost and open-sourced **Plastic Injection Machine**.

In Bioengineering, the design of **a cyclic tensile apparatus for studying cancer cells**; **a multi-sensor system for monitoring acute myocardial infarction using machine learning**; and a **SmartClamp** to monitor cell density of a cell culture growing within a lab-grade incubator.

In Environmental Sustainability, **a predictive model of mangrove health using remote sensing** in Mumbai to help marine biologists, researchers, and governments understand where pollutants flow from; and a **Waste to Energy: Design of a Microwave Induced Plasma Gasification Plant** to transform waste management into a sustainable process.

In Transportation, designs for **a public transport system using modular pods**; and **an optimal public transit network using evolutionary algorithms**.

In Robotics, there were designs for **a Haptic-Audio-Visual Tele-Dental Training Simulation**; a **Haptic Effects for Touch-Screen Devices**; and a **Collaborative Control Design for a Drone Swarm** for visual aerial coverage.

In Cybersecurity, our Computer Engineers designed a **Private Reality Framework**.

And in Resilient Systems, the design of **a reinforced concrete bridge** to ensure connectivity in Abu Dhabi.

According to our Capstone Coordinators, the quality of these reports and projects are some of the best we have seen.

Following graduation, the Engineering Class of 2020 have offers at top graduate schools including NYU, Carnegie Mellon, Johns Hopkins, Boulder, San Diego, Northwestern, Vanderbilt, AIT and KTH; many are considering positions in large corporations including Airbus, Globalfoundries and BCG; and while most of the world is on hold, some of our graduates are taking gap years, deferring studies or completing military service. And some will remain in Abu Dhabi to take up an NYUAD Global PhD Fellowship and Research Fellowship as well work in industry on software engineering.

To the Class of 2020, there is a lot to be proud of with these exceptional accomplishments from this extraordinary semester and we wholeheartedly congratulate all of you for your wonderful academic achievements.

With best wishes for a successful future ahead,

Samer Madanat
Dean of Engineering
NYU Abu Dhabi

A LETTER FROM THE COORDINATORS

Ramesh Jagannathan and Pradeep George

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 and General Engineering) is in developing engineers to solve such real world problems.

The capstone coordinators, Pradeep George and Ramesh Jagannathan, have 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 and design review by a committee of faculty and other professionals.

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 40 senior students in 14 capstone projects. Due to the Covid-19, the scope of the projects were scaled down. The titles and the majors of the team members are listed below:

1. **Design of SmartClamp**
   Majors: Mechanical and Electrical Engineering

2. **Collaborative Control Design for a Drone Swarm**
   Majors: Mechanical, Computer and Electrical Engineering

3. **Design of Reinforced Concrete Bridge**
   Major: Civil Engineering

4. **Design of a Haptic-Audio-Visual Tele-Dental Training Simulation**
   Majors: Computer and Electrical Engineering

5. **Multi-Sensor System for Monitoring Acute Myocardial Infarction using Machine Learning**
   Majors: Computer and Electrical Engineering

6. **Private Reality Framework Design**
   Major: Computer Engineering

7. **Design of Public Transport System using Modular Pods**
   Major: Civil Engineering

8. **Design of Cyclic Tensile Apparatus for studying cancer cells**
   Major: Mechanical Engineering

9. **Designing Haptic Effects for Touch-Screen Devices**
   Major: Electrical Engineering

10. **Design of Plastic Injection Machine**
    Major: Mechanical and Electrical Engineering

11. **Designing a Predictive Model of Mangrove Health using Remote Sensing in Mumbai**
    Majors: Mechanical, Computer and Electrical Engineering

12. **Quad-Turbine Hoverboard Design**
    Majors: Mechanical Engineering

13. **Waste to Energy: Design of a Microwave Induced Plasma Gasification Plant**
    Majors: Mechanical and Civil Engineering

14. **Design of an Optimal Public Transit Network Using Evolutionary Algorithms**
    Majors: Civil and computer Engineering

We 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

Ramesh Jagannathan, PhD
Managing Director, startAD
Vice Provost of Innovation and Entrepreneurship
Associate Dean of Engineering
NYU Abu Dhabi

CAPSTONE PROJECTS

DESIGN OF A SMARTCLAMP

Alia Albastaki (EE) and Keziah Johnson (ME)

SmartClamp is a conical flask housing mechanism that non-invasively monitors cell density of a cell culture growing within a lab-grade incubator. The intended users of the SmartClamp are biologists that are required to manually determine replenishment times by measuring cell density. Measuring cell density is a time consuming process and requires continuous inspection. Replenishment periods are crucial for maintaining a specified cell growth rate, as fresh media is added in order to maintain the culture environment. SmartClamp aims to reduce exposure of the cell culture to the outside environment by calculating replenishment times, thus also simplifying the role of the biologist.
Current solutions are either too complex or too time consuming for the use cases of batch cell growth.

The design of SmartClamp requires the consideration of the following components: an optics unit that measures cell density, a wireless charging unit, and a wirelessly enabled communication unit (to the user). This capstone builds upon previous work under the same advisor, thus, some of the considerations are taken from the previous project.

Capstone Advisor

Andras Gyorgy, Assistant Professor of Electrical and Computer Engineering

COLLABORATIVE CONTROL FOR A DRONE SWARM

Prince Steven Annor (CompE), Alison Waterman (EE) and Sampanna Bhattarai (ME)

Simultaneous localization and mapping (SLAM) allows a drone to navigate and perceive its surrounding environment. In the past, drone systems have employed many technologies to perform relative localization, including various motion detection systems. With the reduced cost of high-resolution cameras and increased computational capabilities of on-board computers, computer vision techniques are now being investigated as additive sensors to inertial measurement unit systems. Several computer vision techniques employ fiducial markers with a recognizable pattern, in order to perform pose estimation between the camera and the attached markers in the collaborating drones. This concept is used for relative drone localization while each drone performs SLAM using cameras, LiDAR and an IMU. In this project, a multi-sensor integration of a LiDAR sensor and a spherical-lens camera is used along with a wireless ad-hoc communication channel to assist in a collaborative control design for a drone swarm for visual aerial coverage purposes. Using simulations, a real-time Voronoi tessellation of the area in NYUAD's Robotics Lab for two of the designed drones flying at the same height is also derived and the area coverage is achieved by commanding each drone to move towards the centroid of its assigned Region of Responsibility.

Capstone Advisors

Anthony Tzes, Program Head & Professor of Electrical and Computer Engineering
Jeremy Teo, Assistant Professor of Mechanical and Biomedical Engineering

DESIGN OF REINFORCED CONCRETE BRIDGE

Armaghan Khan (CE), Paschal Giki (CE) and Roshan Poudel (CE)

Bridges are crucial components of an infrastructure system as they connect communities, individuals, and areas to each other. This is especially true in a place like Abu Dhabi, which has a group of islands that need to be connected to each other for smooth and efficient flow of information and people. The population of Abu Dhabi is set to grow by 1.6 million by the year 2030 as outlined in the Abu Dhabi 2030 plan. In order to have the infrastructure ready to support the growth, new infrastructure projects are proposed and one of those is a new highway bridge between Al Maryah Island and Al Reem Island. The scope of this project dealt with the structural analysis of the various loads involved in the expected bridge, the structural design that would be able to withhold such loads in accordance with AASHTO code requirements, and also a 3-D visualization of the bridge through a software such as Infra-works and Revit. Lastly, the project also entailed a cost estimation and a visualization of the construction to get a better idea of the practicality and materialization of the design by optimization which was done by choosing various components of the bridge like girders and slabs to reduce material wastage. Compared to adjacent bridges, computational design and optimization, which was done using Autodesk Dynamo 2.1 and Autodesk Revit 2020 to reduce costs and also reduce material wastage, is a unique aspect of this bridge. This bridge design was an implementation of one of proposed bridges to be built by 2030, out of the many transportation projects that will take place as the year 2030 approaches and Abu Dhabi's population grows.

Capstone Advisors

Borja García de Soto, Assistant Professor of Civil and Urban Engineering

DESIGN OF A HAPTIC-AUDIO-VISUAL TELE-DENTAL TRAINING SIMULATION

Ken Iiyoshi (CompE), Mahrukh Tauseef (EE) and Ruth Gebremedhin (EE)

Over the past two decades, high-speed communication technologies have revolutionized applications of Tactile Internet (TI) by allowing low-latency data transfer. This has led to the emergence of haptic-based medical simulations that have numerous technical and ethical advantages in medical training. Since dental training is a highly haptic task, tactile internet has the potential to improve the current dental training techniques by allowing communication of motor skills as haptic media. This project designs and implements a detailed, virtual-reality based simulation of a periodontal procedure using haptic technology and a realistic 3D model of the oral cavity. A communication system that allows low-latency transmission of haptic and audio-visual data over a network was developed. The local-hosted communication network performed with minimal overhead; an average delay of 0.62 ms and jitter of 0.53 ms for haptic data, and round trip time of less than 30 ms for audio-visual data. This system enables effective supervised training over a physical distance and is more interactive than commonly used non-haptic computer simulations.

Capstone Advisors

Mohamad Eid, Assistant Professor of Electrical and Computer Engineering

MULTI-SENSOR SYSTEM FOR MONITORING ACUTE MYOCARDIAL INFARCTION USING MACHINE LEARNING

Lujain Ibrahim (CompE), Munib Mesinovic (EE) and Kai-Wen Yang (EE)

Cardiovascular disease is the number one cause of death globally, and in the UAE specifically, Acute Myocardial Infarction (AMI) takes more lives than any other health condition. One of the major approaches towards tackling this formidable public health epidemic is by raising awareness and developing early-detection mechanisms so that people have enough time to preemptively tackle this health challenge. Medical research tells us that upon detection of an AMI, a person has up to 90 minutes to seek medical attention and avoid permanent serious tissue damage and in a lot of cases, death. Our Capstone Design Project seeks to gather the physiological signals our body exhibits leading up to an AMI by using ECG and Pulse Oximetry sensors in a wearable armband and use machine learning analysis on the real-time collected data to provide personalized feedback to the user on their cardiovascular health and AMI risk condition. A printed circuit board (PCB) for the monitoring of cardiovascular parameters was designed and validated by EAGLE early-testing. Over 900,000 ECG, age, and sex samples obtained from the ECG-ViEW database have been used to train machine learning models, including naive bayes, logistic regression, CNN, and RNN, that predict the onset of AMI. High prediction accuracy of 90.5% (CNN) and 89.2% (RNN) have been achieved, demonstrating the promising application of early identification of acute myocardial infarction.

Capstone Advisors

Mohamad Eid, Assistant Professor of Electrical and Computer Engineering

PRIVATE REALITY FRAMEWORK DESIGN

Brandon Chin Loy (CompE) and Daria Zahaleanu (CompE)

In the digital world, the average user works with a large amount of personal data on a daily basis that is processed into countless websites and applications, which include social media, banking, education and medical services. This data, encrypted or unencrypted, is often stored in the user's personal devices. When these devices are connected to the internet, there is an opportunity for third parties to digitally access such data without the user's permission, which compromises privacy. In the first half of 2019, more than 3,800 publicly-disclosed data breaches in companies have been recorded, exposing 4.1 billion compromised records. This project serves to build a framework using a head-mounted display (HMD) to enable privacy-preserving applications by allowing the user to handle his or her unencrypted data without using digital communication. An application was developed in the HMD in which data transmission was carried out over the visual spectrum, using photons as information carriers to eliminate the need for digital connections. It enables the user to scan visually encoded ciphertext on a computer screen and view the plaintext in the HMD.

Capstone Advisor

Michail Maniatakos, Associate Professor of Electrical and Computer Engineering

DESIGN OF PUBLIC TRANSPORT SYSTEM USING MODULAR PODS

Adnan Dekeidek (CE), Farah Shabaz (CE) and Sara Alanis (CE)

Private cars outperform public bus systems in urban networks based on comfort, flexibility, and convenience. With the increasing issues of overpopulation and climate change, more effective alternatives are needed to move people away from private cars. At the same time, bus ridership has seen a continuous decrease over the last 10 years. As of right now, public buses are not an attractive option for people to shift away from private cars. To address this issue, we investigated the use of autonomous modular pods that have the flexibility to attach and detach to provide a service that fits better the demand. As a proof of concept, we considered a corridor network with a varying degree (from 0% to 100%) of modular pods to traditional buses that was designed following the already operational M23 bus line in Manhattan, New York. The results for a transit system with a 2 min headway showed there is a 73% reduction in the average waiting time for users, resulting in $992 per hour of user cost savings when the transit system is composed of 100% pods as opposed to 100% traditional buses. The overall results indicate that the total cost is reduced when increasing the percentage of pods for all testing headways. This shows the potential of modular autonomous vehicles for future public transit systems.

Capstone Advisors

Monica Menendez, Associate Professor of Civil and Urban Engineering
Borja García de Soto, Assistant Professor of Civil and Urban Engineering

DESIGN OF CYCLIC TENSILE APPARATUS FOR STUDYING CANCER CELLS

Adnan Ali-Hassan (ME), Amr El Ashmouny (ME) (not pictured here) and Gladys Tarisai Mwedzi (ME)

Studying the effect of mechanical forces on the adhesiveness and migration of cancer cells is a field of interest among many researchers. Several stretching devices have been designed and implemented to study functional responses of various cells by inducing elastic deformations (tensile, compressive, or shear) on cells. However, these devices, despite being very compatible with advanced microscopy techniques, offer many limitations. Some of these devices' drawbacks include: impracticality in clamping the membrane to the device, inconsistency in the periodicity of the strains applied to the cells, non-uniformity of the strain distributions over the membrane surface, and inapplicability of running multiple membranes at once. This project aims to solve these flaws by creating a custom-made tensile device that fits in an incubator as well as on a microscope stage. These flaws are observed in the use of servo motors for mechanical stretching of cells, which is the most commonly used stretching mechanism available. Innovating the current servo motor stretching apparatus design was one possibility that was considered, but was disregarded after a more efficient and cost-effective mechanism was found. This mechanism involves the use of pneumatic pressure. There are two possible ways of applying such method, which is through vacuum or by applying pressure. For our design, cyclic stretching is optimal, so applied pressure will be used to stretch the cultured cancer cells, as this method is more efficient for this type of stretching. The chosen mechanism was simulated multiple times on Comsol, ANSYS, and Solidworks, with different materials tested and different geometrical shapes for the cultured cells' region. The project is yet to be built and tested, and the results will be compared to those of the simulations.

Capstone Advisor

Mohammad Qasaimeh, Assistant Professor of Mechanical and Biomedical Engineering

DESIGNING HAPTIC EFFECTS FOR TOUCH-SCREEN DEVICES

Youssef Azzam (EE) and Mariam Raslan (EE)

In an era defined by technological advancements and improvements, research and development have been directed towards making one's life easier. Great efforts have been put forth by scientists and industry professionals all over the world towards smart products for the welfare of mankind. With the increasing use of touch-screen devices, the global multi-touch screen market was evaluated at USD 8.47 billion in 2018. In this project, the design of haptic effects is presented to cater for the touch-screen market and its users worldwide. The goal of our capstone project is to introduce tactile interaction to touch-screen devices. Our project entails designing haptic effects for Graphical User Interface (GUI) elements on touch-screen devices and conducting a series of human studies to evaluate them. The design concept includes developing a library of haptic effects that are easily integrable and applicable to haptic graphical user interfaces (GUIs) based on analyzing touch interactions and user evaluations. Throughout the course of this project, the haptic effects library developed focuses on how users perceive the aforementioned effects in terms of multi-task interactions with the touch-screen device. The haptic feedback effects library generated via our gradient based technique (friction control) and audio waveforms (click effects) allows better identification of GUI elements, hence, meeting our criteria for testing realism and affordance. Together with the friction control provided on the touch-screen, and using the gradient based technique, the realistic tactile sensation met our expectations of better identifying the GUI elements upon interaction. User evaluation was not achieved due to the impact of COVID-19 on this project, however, expert evaluation and testing cross checked the affordance of physical interactions. Usability and performance should be carried forward and tested in person for better results. Through the implementation of our project, we aim to bring back life to touch-screen devices through haptic technology.

Capstone Advisors

Mohamad Eid, Assistant Professor of Electrical and Computer Engineering

DESIGN OF PLASTIC INJECTION MACHINE

Kazi Owais Ahmed (ME), Muhammad Rafay Ashfaq (EE) and Hamza Haider (EE)

The goal of this project is to further develop the mechanical and electrical engineering aspects of a previously existing plastic injection machine. Existing injection machines melt shredded plastic into a mold, cools it down and makes an object from negative mold shape. Plastic is melted using an arrangement of band heaters in a steel tube, manually applied force into the tube pushes molten plastic down. For our capstone, the group focused on improving a small-scale low-cost injection machine by adding features like a touch user interface, electric screw jack for handsfree piston operation and an advanced heating system. These were successfully designed and implemented. The blueprints and schematics will be published opensource in order to provide the global community with the opportunity to optimize their machines.

Capstone Advisors

Felix Hardmood Beck, Assistant Professor of Practice of Design
Mahmoud Rasras, Associate Professor of Electrical and Computer Engineering
Rafael Song, Associate Professor of Mechanical and Biomedical Engineering

DESIGNING A PREDICTIVE MODEL OF MANGROVE HEALTH USING REMOTE SENSING IN MUMBAI

Baleegh Ahmad (EE), Sohail Bagheri (CompE), Prajna Soni (ME) and Antony Tahan (EE)

(Clockwise from left)

This project provides a novel solution of consolidating aerial imagery and predictive modeling as functions of changes in the built and natural environment to provide data-driven predictions to help conserve mangrove health in Mumbai's Thane Creek. The final model design will provide a better understanding of how pollutant flow information can supplement satellite imagery data to better identify sources of polluted discharge that impact mangrove health. The project tracks mangrove cover in the region using unsupervised classification on satellite imagery through color cluster analysis. It identifies a trend line for seasonal variation in mangrove cover, thus allowing for deviations due to anthropogenic activities to be identified. A trend line with an error margin of 17.9% was calculated, therefore any decrease of mangrove cover greater than the critical point would be flagged, allowing the instance to be investigated further. The project stems from the lack of an appropriate tool that is able to quantify the effect that changes in the local environment can have on mangroves. The proposed tool is envisioned to help marine biologists, researchers, and governments understand where pollutants flow from and what path they take to impact mangrove health negatively.

Capstone Advisors

Matthew Karau, Lecturer of Engineering Design

QUAD-TURBINE HOVERBOARD

Muhammad Shehryar Hamid (ME), Alexander Fleming (ME), Edvards Likovskis (ME) and Febin Thapa Magar (ME)

(Clockwise from left)

The Quad-Turbine Hoverboard Project aims to design a single-user flying vehicle using turbines in place of electric rotors conventionally implemented in quad-engine drone type flying objects. The board aims to be user accessible and simple to use, mimicking the user experience and aesthetic of a skateboard to replicate the “Hoverboard” commonly seen in science fiction films. To this end true conventional flight is not the desired outcome, rather a form of motion primarily within a stable lateral plane to create the “hovering” experience. Several existing prototypes with similar goals have been developed but all either rely heavily on impractical infrastructure to allow magnetic levitation or forsake the sleek, simple experience of a “hoverboard” in place of a complicated flight procedure.

The project will be conducted in 3 stages. The 1st stage will be a literature review and investigation of applicable concepts, and research into types of equipment required for the design. The 2nd stage will be the design of the board and the individual components, and the 3rd stage will be a focus on manufacturing, testing and adjustments of the prototype.

At the end of the project we expect to arrive at a working prototype that can lift a considerable weight off the ground and stably hover at a certain altitude. Given the time constraints of the project, lateral motion and other elements of user control are saved for a future iteration of the project in order to focus on the core components of design and ultimate function.

Capstone Advisors

Philip Panicker, Senior Lecturer and Coordinator of Engineering Academic Laboratories

WASTE TO ENERGY: DESIGN OF A MICROWAVE INDUCED PLASMA GASIFICATION PLANT

Doovaraha Maheswarasarma (ME), Dhruvi Joshi (CE) and Raunak Shrestha (CE)

Waste is defined as the unwanted materials produced by any activity. Waste-to-energy (WTE) technologies provide the necessary tools to redefine waste as a raw material or resource that plays a crucial role in the development of a circular waste economy. Currently, landfilling is the most widely practiced waste management strategy which has a large and wide range of environmental impacts. This project proposes a sustainable WTE facility design with Microwave Induced Plasma Gasification (MIPG) as its core technology to convert Municipal Solid Waste (MSW) into energy and slag. The circular economy created through the facility mimics that of the environment in which resources discarded by one organism are used by another organism. The proposed solution can be retrofitted on top of existing waste management or WTE systems. The design aims to transform waste management into a sustainable and ecologically friendly process. The target location selected for the plant is in the Emirate of Abu Dhabi.
The design of the WTE plant includes aspects of structure, transportation, and waste processing which are required to produce energy from waste. The design is further supported by an Environmental Impact Assessment that evaluates compliance of the plant with UAE rules and regulations.

Capstone Advisors

Khaled Shahin, Senior Lecturer and Coordinator of Engineering Assessment
Philip Panicker, Senior Lecturer and Coordinator of Engineering Academic Laboratories

DESIGN OF AN OPTIMAL PUBLIC TRANSIT NETWORK USING EVOLUTIONARY ALGORITHMS

Dogukan Avci (CompE) and Meredith Raymer (CE)

Public transit design has been optimized through minimization of an objective function made up of the user and agency costs. However, societal costs, such as the environmental impact of congestion, has not been fully studied. With increasing environmental concerns due to the large impact of transportation emissions, assessing the external cost of all transportation modes on the environment is especially important. In this paper, a cost function was created that takes into account the agency and user costs as well as the environmental impacts of the transportation system through CO2 emissions. Through use of covariance matrix adaptation evolution strategy (CMA-ES), a methodology for the design of public transit networks that minimizes this cost was created and tested. The methodology was implemented using the Simulation of Urban Mobility (SUMO) (Version 1.3.1; Institute of Transportation Systems, 2018) to reflect traffic scenarios that were included as inputs to the cost function for 5 routes and a headway of 10 minutes. When the optimization was initiated with a random set of stops, a minimum value of $3,418,128 was found. When the optimization was started with a set of sequential stops, a minimum value of $1,087,693 was found. Both, however, are higher than the benchmark solution of $734,395. Since this methodology did not find a solution more optimal than analytical methods, further research on the applicability of CMA-ES to transit design is needed to determine its effectiveness.

Capstone Advisors

Yi Fang, Assistant Professor of Electrical and Computer Engineering
Borja García de Soto, Assistant Professor of Civil and Urban Engineering
Monica Menendez, Associate Professor of Civil and Urban Engineering


CLASS OF
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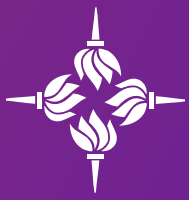

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