NYU ABU DHABI ENGINEERING CAPSTONE PROJECTS

CLASS OF 2018

Introduction from the Dean

The Fifth NYU Abu Dhabi Engineering Capstone Festival is a platform for our Class of 2018 Seniors to showcase their year-long Capstone Projects using design solutions to solve real world problems. It is also a celebration of the completion of their projects – the culmination of their hard work throughout 2017-18.

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. It also provides students with an opportunity to integrate technical, human, aesthetic and business concerns with applied design solutions.

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A defining feature of the Engineering undergraduate experience is the Capstone, representing the highest aspirations of undergraduate intellectual development, creativity, and engagement with original creative work. This booklet celebrates only a small piece of the Seniors' innovative and creative projects, which are aligned with today's Engineering advances and our own research priorities as follows:

In Cyber Security, our students designed chips to thwart cyber-attacks and secure netlists through a resilient Logic Locking Framework; developed Efficient and Lightweight Cryptographic Primitives for Extreme Embedded Systems Environments; and proposed Improving Wi-Fi for High Density Environments by utilizing the signal strength received from the access point to solve hidden terminal problems at the overlap of Wi-Fi networks.

In Robotics, they developed an interactive Handwriting Learning Platform to engage sensory responses through haptic stimulus and speed up the handwriting process for children by also working closely with local schools; and created a Raspberry Pi Portable Supercomputing cluster that explored tradeoffs between processing power consumption and performance and mounted the cluster onto a portable iRobot.

In Future Cities and Transportation, a Regional Airport Terminal Design was proposed that would cater for close-range flights, reduce congestion on the main UAE internationals airports and incorporate aspects of local culture and architectural design.

In Bioengineering, our seniors developed a cytometer for Single Cell Analysis of Algal Cells Using Closed Loop Channel to track the properties of cells to provide insight into the dynamics, heterogeneity and hierarchy of these cells; and a non-invasive Automated Fetal Kick Monitoring Belt for convenient daily monitoring to detect any changes in fetal activity.

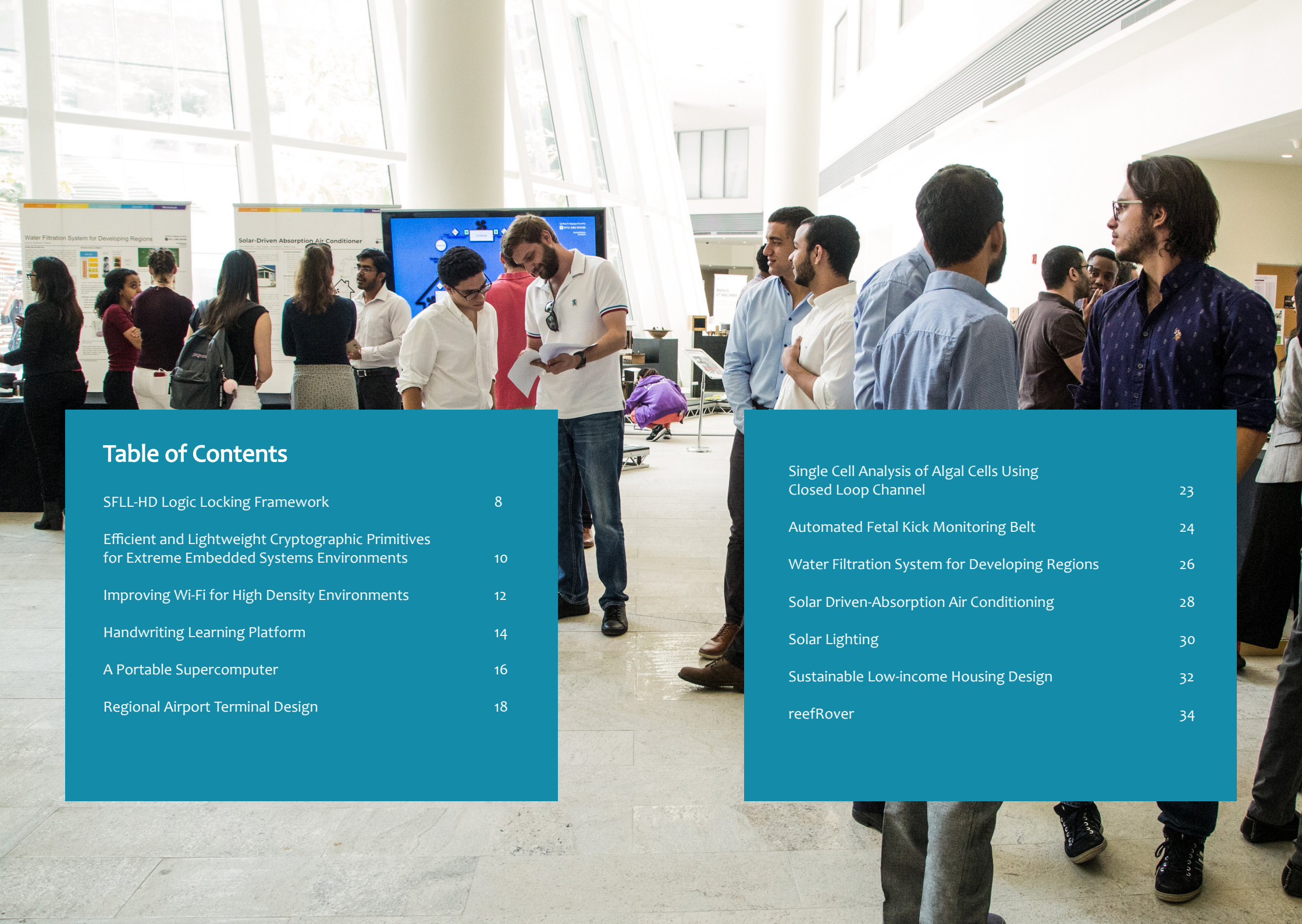
In Environmental Sustainability, they developed: an economical Water Filtration System for Developing Regions using an advanced, multi-step xylem-based filter to remove physical, chemical and biological contaminants; non-toxic and non-polluting Solar Driven-Absorption Air Conditioning that would operate independently from the grid; a low-maintenance quality Solar Lighting system with minimal IR and no UV component, using minimal energy; and a resilient and structurally sound Sustainable Low-income Housing Design for low income communities.

And finally, with the importance of Coral Reefs to the UAE, our reefRover team envisioned a fully operational, autonomous ROV to survey the reefs on a larger scale to provide the opportunity to capture more high-quality images and ensure data quality. This multidisciplinary project is also open-source allowing anyone across the world to develop and deploy the reefRover to further expand and analyze the data of this threatened natural resource.

These innovative projects are a dress rehearsal for the world of Engineering and we congratulate our graduates on their achievements. Our very best wishes for a truly exciting future ahead,

Sincerely

Samer Madanat
Dean of Engineering, NYU Abu Dhabi



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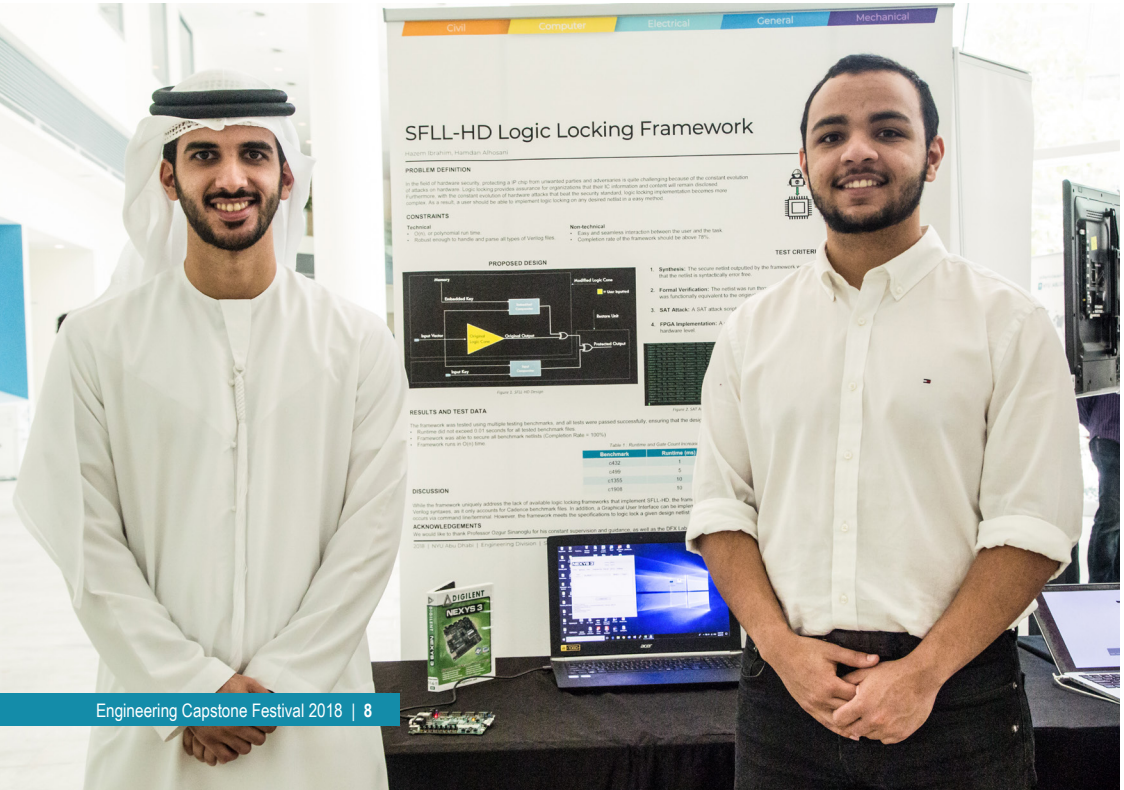
Hazem Ibrahim and Hamdan Al-hosani

SFLL-HD Logic Locking Framework

IC netlists are valuable assets by nature since it holds the basic design of electronic chips. However, the process of manufacturing chips is complicated as there are multiple threats from untrusted users and fabricators. Logic Locking has been perceived as a promising and reliable defense mechanism against intellectual property piracy, reverse engineering and overbuilding attacks. Stripped Functionality Logic Locking, or SFLL, is proven to be resilient to all types of hardware attacks on a netlist. SFLL strips some of the functionality of the circuit and hides it in the form of a secret key(s), thereby, rendering the on-chip implementation functionally different than the original netlist. Currently, implementing any logic locking framework on a given netlist is complicated.



In this paper, we propose a software framework that implements SFLL on any Verilog netlist. The software will produce a secured netlist that can thwart multiple attacks such as SAT attack, removal attack and sanitization attack. In addition, verification of the correct implementation of SFLL security will be completed to ensure the validity of the software framework.

Capstone Supervisor: Ozgur Sinanoglu, Associate Professor of Electrical and Computer Engineering

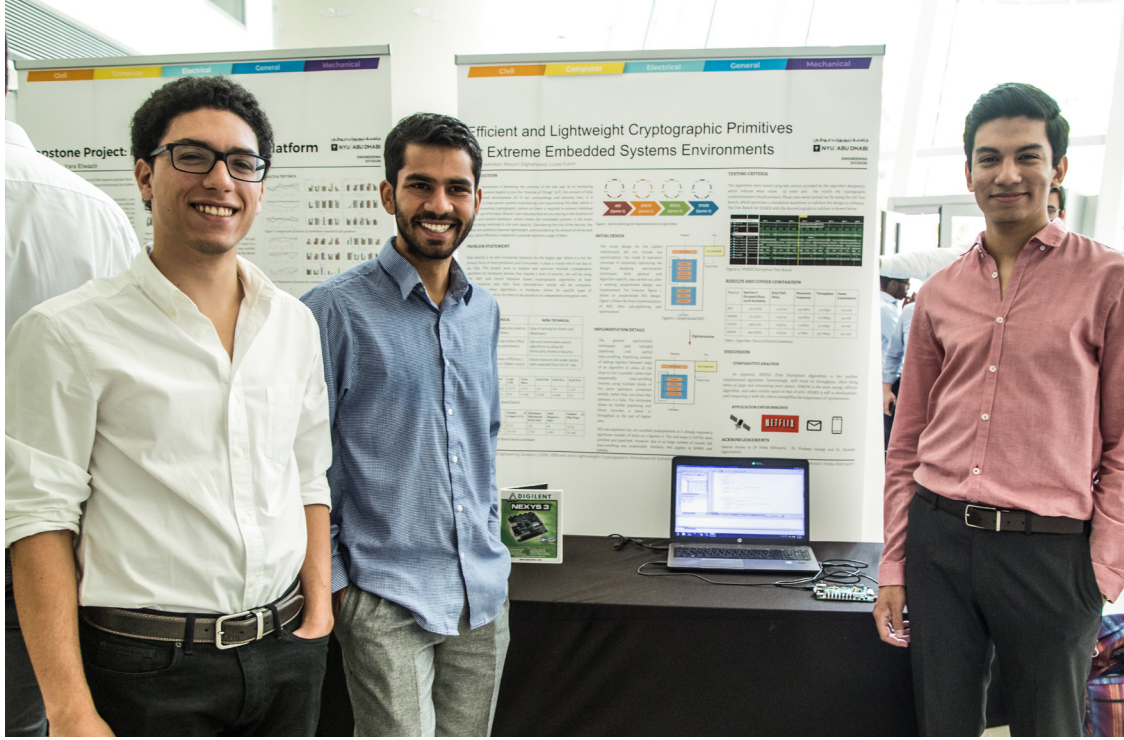
Prasant Adhikari, Mounir Elgharbawy and Lucas Futch

Efficient and Lightweight Cryptographic Primitives for Extreme Embedded Systems Environments

The objective of the project was to evaluate and optimize multiple encryption algorithms using multiple metrics to generate a benchmarkable and balanced algorithm. Most implementations focus on only optimizing for one evaluation metric, leaving an unbalanced implementation. This project was approached by deciding to observe the trade-offs that occur when using optimization strategies such as loop unrolling or pipelining, and making sure a well-balanced algorithm was achieved with the desired performance.

This project explored AES, NORX, TEA, XTEA, and SPARX, and applying permutations of strategies and techniques and analyzing their effect on observable metrics. Different families of encryption algorithms are being explored with the hopes that the benchmarks to be generated would be applicable into future research and iterations of hardware encryption.

Capstone Supervisors: Hoda Alkhzaimi, Research Assistant Professor and Director of the Center for Cyber Security

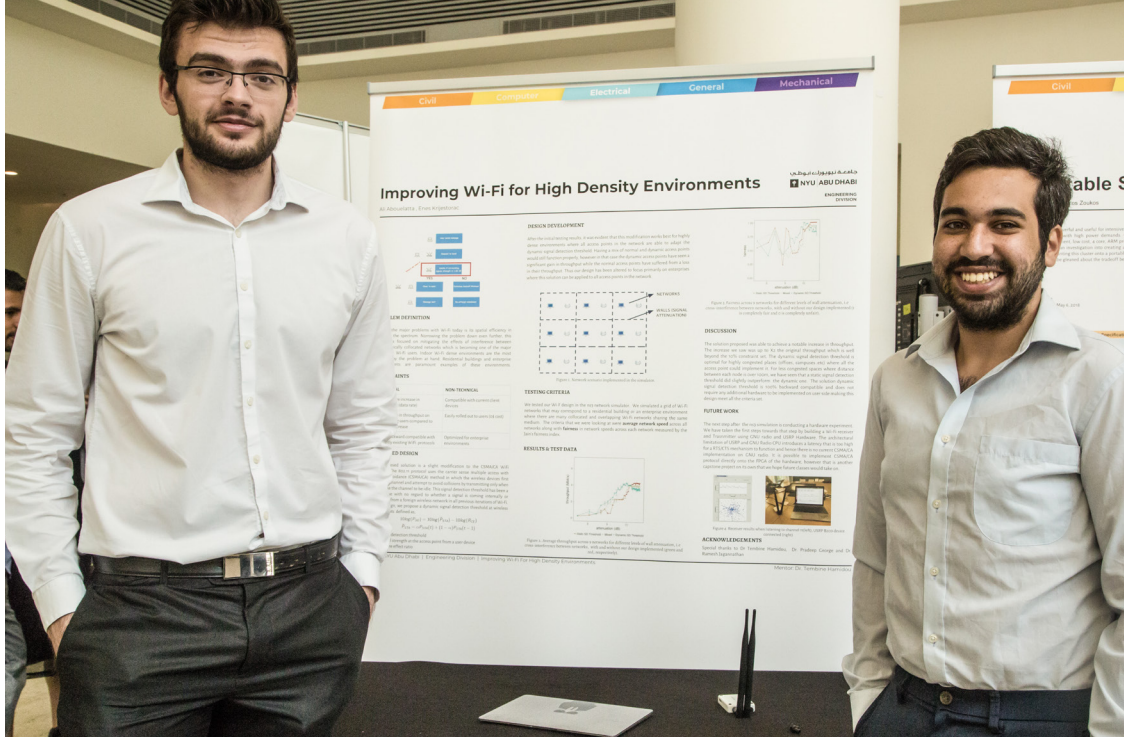


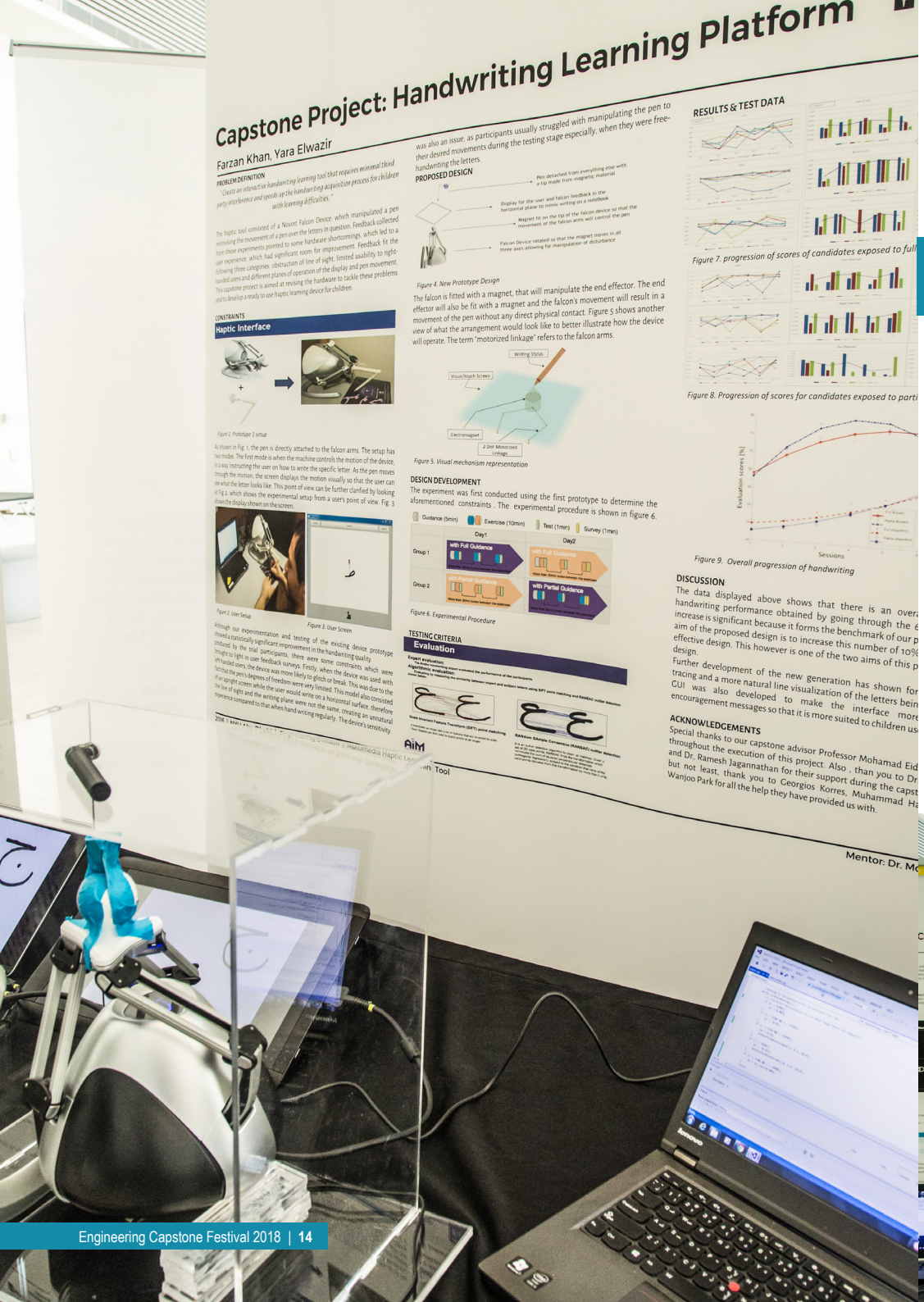
Ali Abouelatta and Enes Krijestorac

Improving Wi-Fi for High Density Environments

Due to the improvements made to the wireless standard in the past two decades, wireless has overtaken wired as the dominant form of communication today. To meet the future data traffic needs, the Wi-Fi standard of today will need to be significantly improved in both the quality of service and security. Since the number of Wi-Fi networks in both residential and enterprise environments is increasing rapidly, the interference between geographically collocated networks is becoming one of the significant issues of Wi-Fi. This happens because access points of different Wi-Fi networks operate independently. A device located at the overlap of two or more networks may not be able to receive data because access points from various networks are interfering. This is called the hidden terminal problem. Given that the hardware processing capabilities are increasing, in the future, the signal detection threshold of CSMA/CA may become a dynamic value. In this paper, we propose using a dynamic CSMA/CA signal detection energy threshold instead of the currently static one. The signal detection threshold will utilize the signal strength received from the access point to solve the hidden terminal problem more efficiently at the overlap of Wi-Fi networks.

Capstone Supervisor: Tembine Hamidou, Assistant Professor of Electrical and Computer Engineering



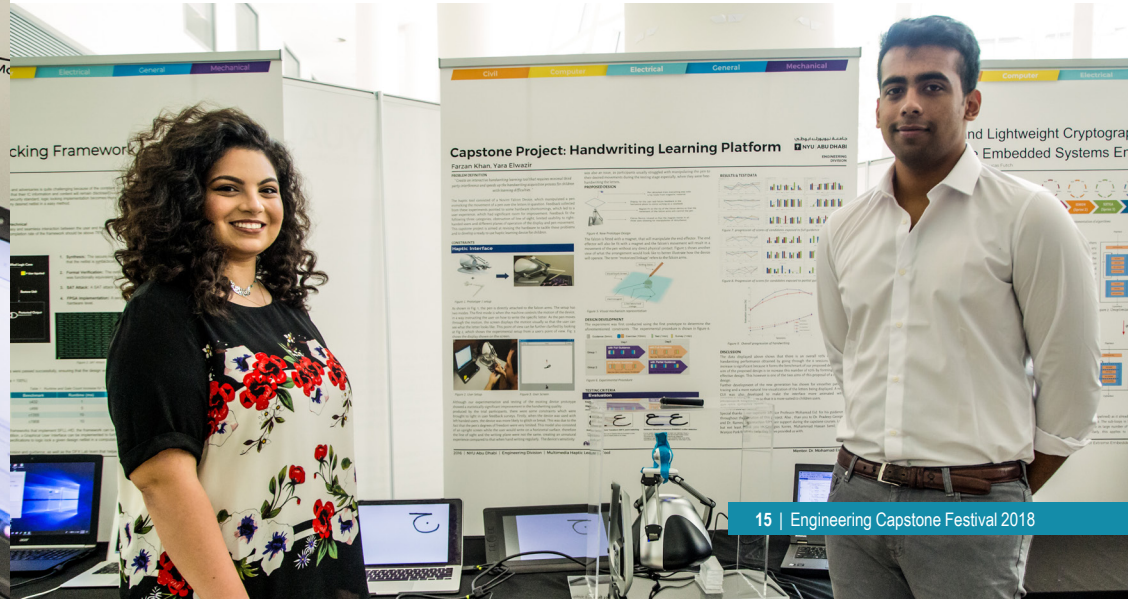


Farzan Khan and Yara Elwazir

Handwriting Learning Platform

Studies have shown that incorporation of a haptic modality expedites the handwriting learning process and improves retention. A prototype of a haptic learning device was developed in the Applied Interactive Media Lab and experiments conducted on the device showed the effectiveness of the device in teaching non-Arabic speakers how to write Arabic letters. This consisted of a Novint Falcon Device, which manipulated a pen mimicking the movement of a pen over the letters in question. Feedback collected from these experiments pointed to some hardware shortcomings, which led to a user experience, which had significant room for improvement. Feedback fit the following three categories: obstruction of line of sight, limited usability to right-handed users and different planes of operation of the display and pen movement. This capstone project was aimed at revising the hardware to tackle these problems and to develop a ready to use haptic learning device for children. The second generation device will then be tested through a revised experimental procedure and the results will be compared to the results collected with the first generation device.

Capstone Supervisor: Mohamad Eid, Assistant Professor of Electrical and Computer Engineering



Yasmin Farhan and Christos Zoukos

A Portable Supercomputer

There is much to gain from building a smaller scale supercomputer out of Raspberry Pis – combining the processing power of these low cost, powerful computers allows us to beam a powerful light onto the field of supercomputing, and mounting this cluster onto a portable iRobot base allows us to glean valuable information about the tradeoff between power consumption and performance. This is a direct result of there being a limited reserve of power, our primary technical constraint, as supplied by the iRobot's battery, which has a capacity of 3300mAh and outputs 14.4 V. By carrying out performance benchmarking and power consumption assessments, we can take several approaches to ensuring that the ideal final design satisfies the design criteria we have established, and is built given the additional technical and non-technical constraints we must consider.

These approaches can be considered the solution concepts to be explored as we scale up the cluster: the main three are the Raspberry Pi Model type, the network topology of the cluster, and the load on the operating system.

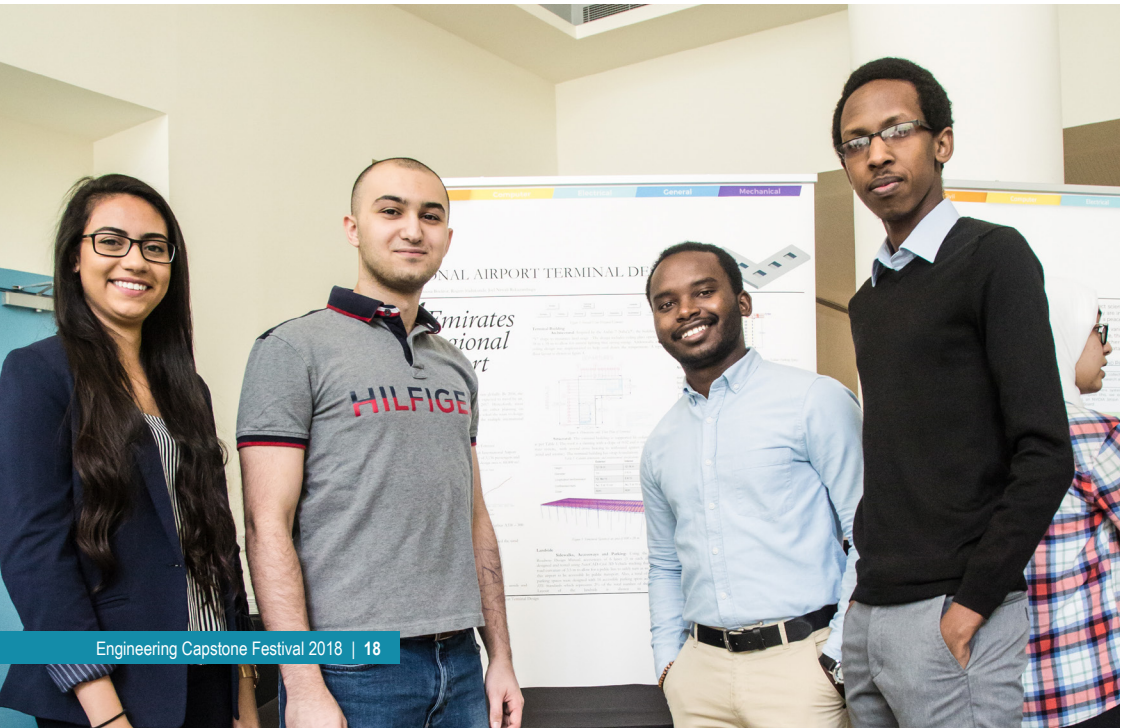
Additional aspects of the project to explore as we progress further are the enclosure of the cluster once it is mounted, the parallel workload, and remote control of the cluster. The main design criteria we hope to fulfill include maximizing performance/watt, maximizing battery lifetime, and achieving a minimum runtime as dictated by the endpoint of the parallel task to be carried out by the cluster.

Capstone Supervisor: Michail Maniatakos, Assistant Professor of Electrical and Computer Engineering

Moosa Awad, Yousteena Bocktor, Rogers Iradukunda and Joel Ntwali Rukazambuga

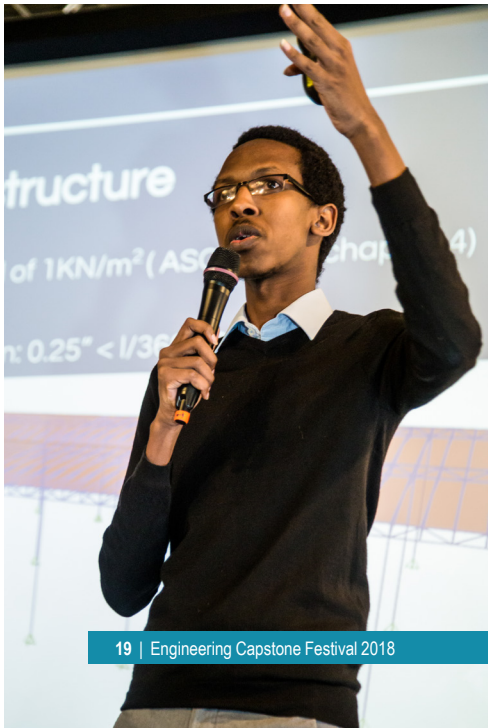
Regional Airport Terminal Design

The main purpose of this project is to design a regional airport in Abu Dhabi that would cater for close-range flights in order to reduce congestion on the main airports in the United Arab Emirates. The regional airport will cater for flights going to and coming from the Middle East and North Africa specifically. Multiple concepts have been proposed for the design of the airport with the main factors being cost-efficiency, incorporating elements of Emirati culture, and providing for the maximum expected capacity. Through the use of appropriate tools, such as Pugh Charts, it has been decided that the final design would be as follows: the Arabic number 7 as the architectural shape; a rectangular parking garage; a rigid pavement; reinforced concrete as the structure's material; and a layout with the arrivals and departures on the same floor but on opposite ends.



Based on the transportation study to forecast the following 15 years demand, a terminal area of 23,000,000 m² would be designed. It would be expected to be dealing with a peak hourly demand of 3,136 passengers and 16 flights. A supplemental parking structure that would be catering for 5% of the daily capacity with 1,500 parking lots. The runway design and the wind analysis of the project would be based on the aircraft Airbus A330 that has a capacity of 277 passengers.

Capstone Supervisor: Khaled Shahin, Senior Lecturer of Civil Engineering



جامعة نيويورك أبوظبي

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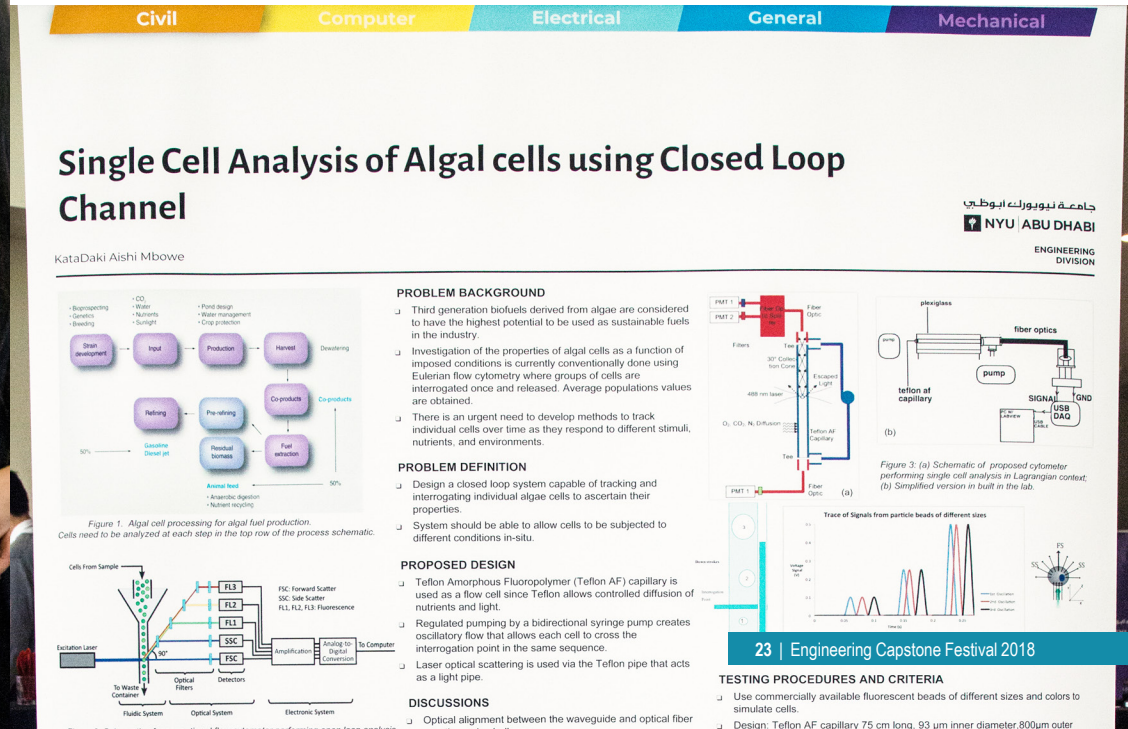
KataDaki Aishi Mbowe

Single Cell Analysis of Algal Cells Using Closed Loop Channel

The purpose of this capstone is to develop a cytometer that will perform single cell analysis of algal cells. Conventional Cytometers provide information corresponding to the Eulerian specification of flow field. Our project involves the design of Lagrangian cytometer can track the properties of each and every cell within the population over the growth period and can provide insight into the dynamics, heterogeneity, and hierarchy of the cell populations between individual cells. The capstone design will enable measurement of lipid production in algal cells upon genetic manipulation. This cytometer will enable rational selection and metabolic engineering of microalgae necessary for the optimal production of biofuels.

Capstone Supervisor: Sachin Khapli, Assistant Professor of Engineering and Sunil Kumar, Professor of Mechanical Engineering

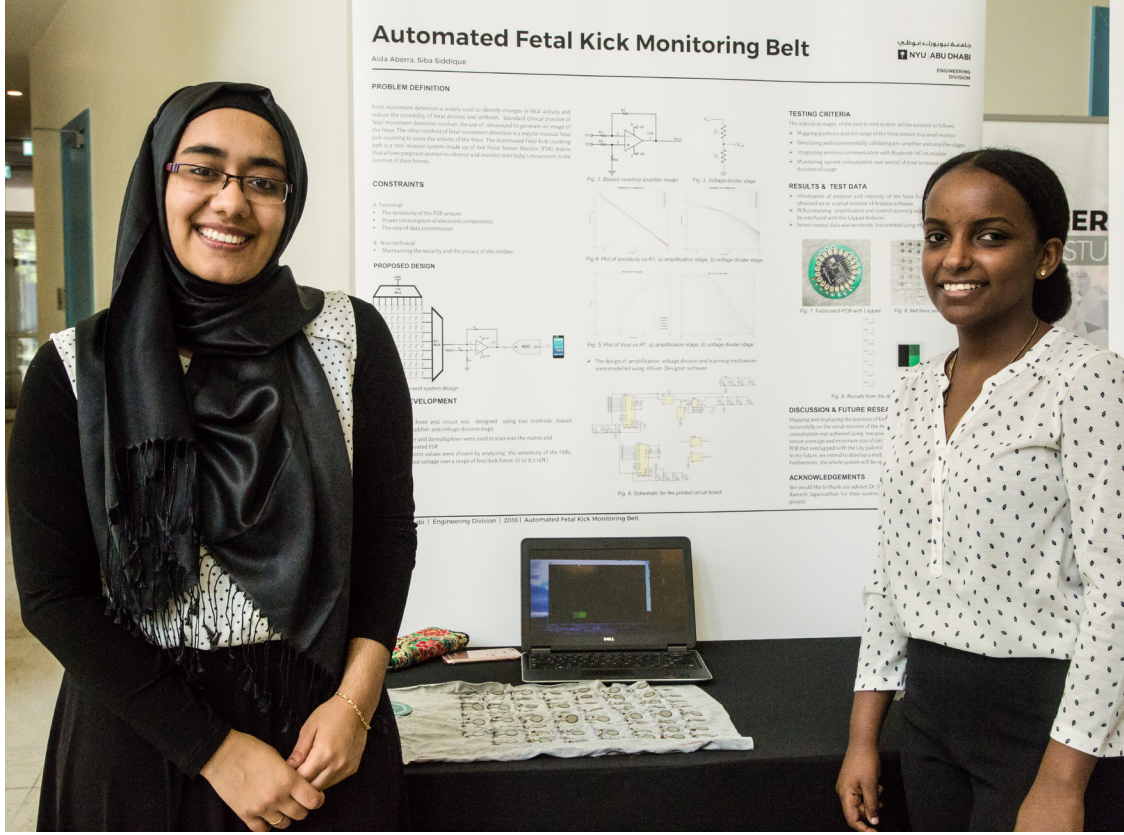


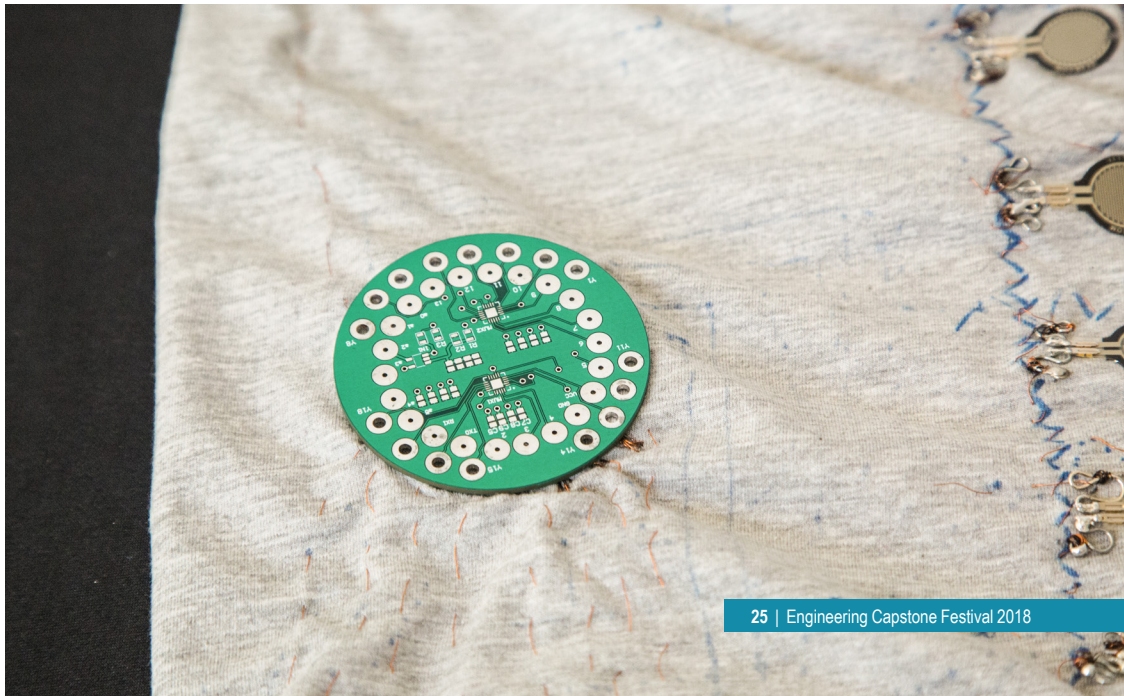
Aida Aberra and Siba Siddique

Automated Fetal Kick Monitoring Belt

Monitoring fetal well-being is a crucial procedure in modern obstetrics. Among the many methods of checking fetal well-being, fetal movement detection is widely used to identify changes in fetal activity and reduce the possibility of fetal distress and stillbirth. Standard clinical practice of fetal movement monitoring involves the use of ultrasound which relies on high frequency sound waves to generate an image of the fetus. Doctors also recommend pregnant women to use fetal kick counting as a way to monitor their baby's health beginning from the third trimester. Fetal movement counting is a method by which pregnant women quantify the movements they feel to assess the condition of their baby. While fetal kick can vary on daily bases, a significant deviation from the normally expected value, which is 10 kicks in 2 hours, indicates that the woman should consult her medical provider. While fetal movement can be observed using ultrasound imaging, a non-invasive and home based monitoring system is still in development to enable pregnant women perform self-administrated monitoring. In this project, an Automated Fetal Kick system will be developed using a matrix of Force Sensitive Resistors(FSRs), and multiplexers. The final product integrates the array of sensors in a maternal belt, and sends information about the number of kicks and the frequency to a cell phone via wireless communication. The system will be able to detect a fetal force which found to be 0.52 ± 0.15 N, with more than 90% overall efficiency.

Capstone Supervisor: Sohmyung Ha, Assistant Professor of Electrical and Computer Engineering

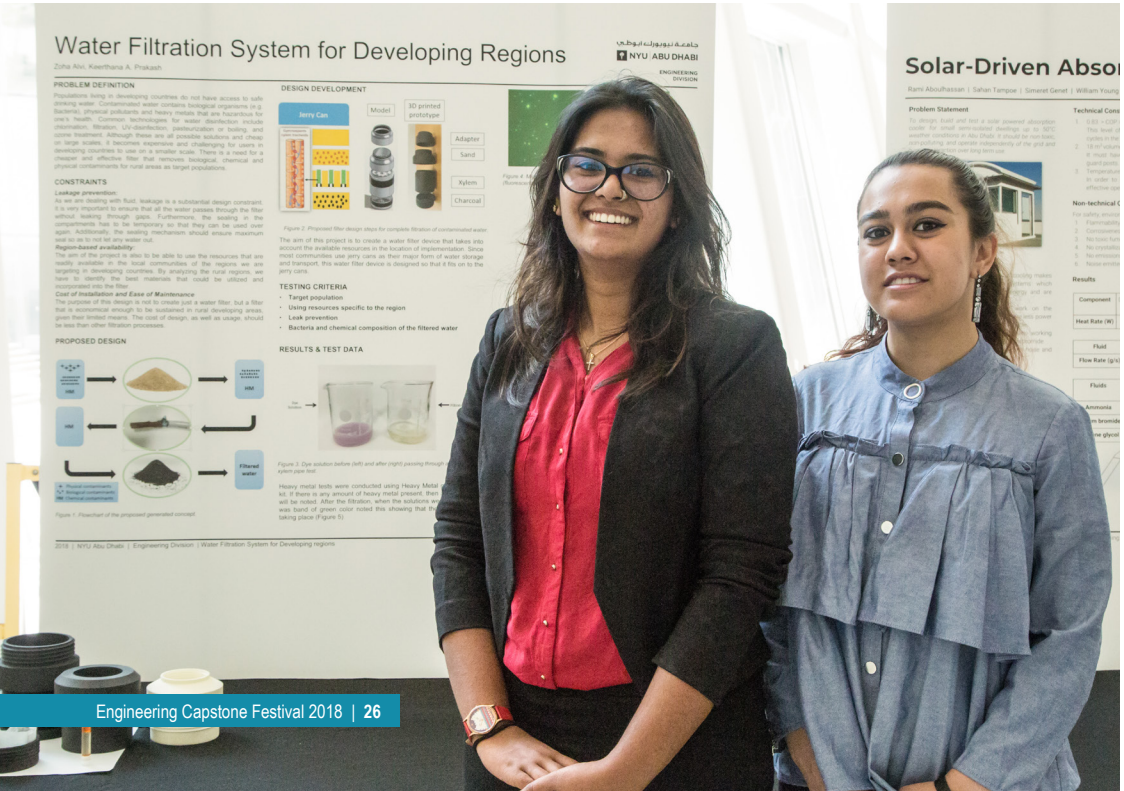


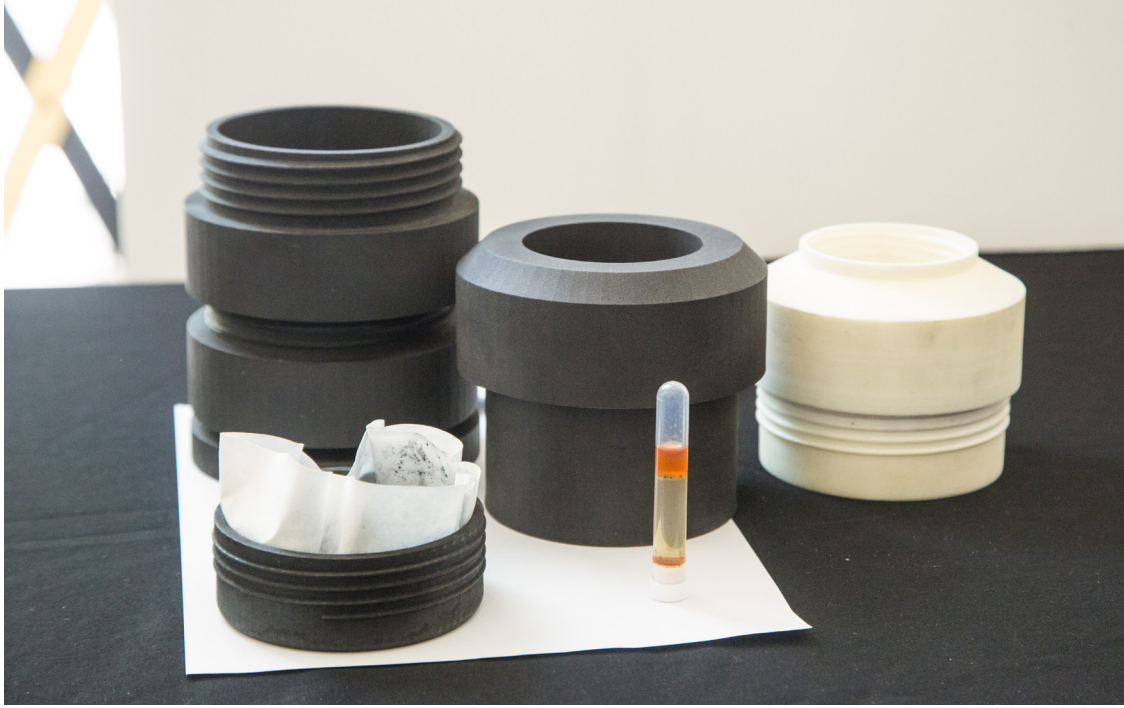


Zoha Alvi and Keerthana A Prakash

Water Filtration System for Developing Regions

Potable or drinkable water is defined as having acceptable quality in terms of its physical, chemical and bacteriological parameters so that it can be safely used for human consumption. Among the various water pollutants, biological contaminants are the most fatal in developing regions. The most common water pathogens consist of bacteria, viruses and protozoa, and are major contributors to the most common and widespread health risk associated with drinking water. The only possible way to achieve potable water is to carry out disinfection processes. According to the research conducted at MIT, nano-pores in Gymnosperm plant xylem has been identified as an efficient filter of bacteria due to the "short tracheid that would force water to flow through pit membranes".





The availability of this plant in the region makes it an affordable and reliable source to be incorporated in a water filter device. In addition, adding a compartment for sand and charcoal each makes the water filter more efficient at filtering out the physical, chemical and biological contaminants. In this capstone project, we aim to achieve an advanced multi-step xylem-based filter that can filter bacteria and heavy metals without blockage problems at an economical cost to people residing in developing regions who do not have access to potable water.

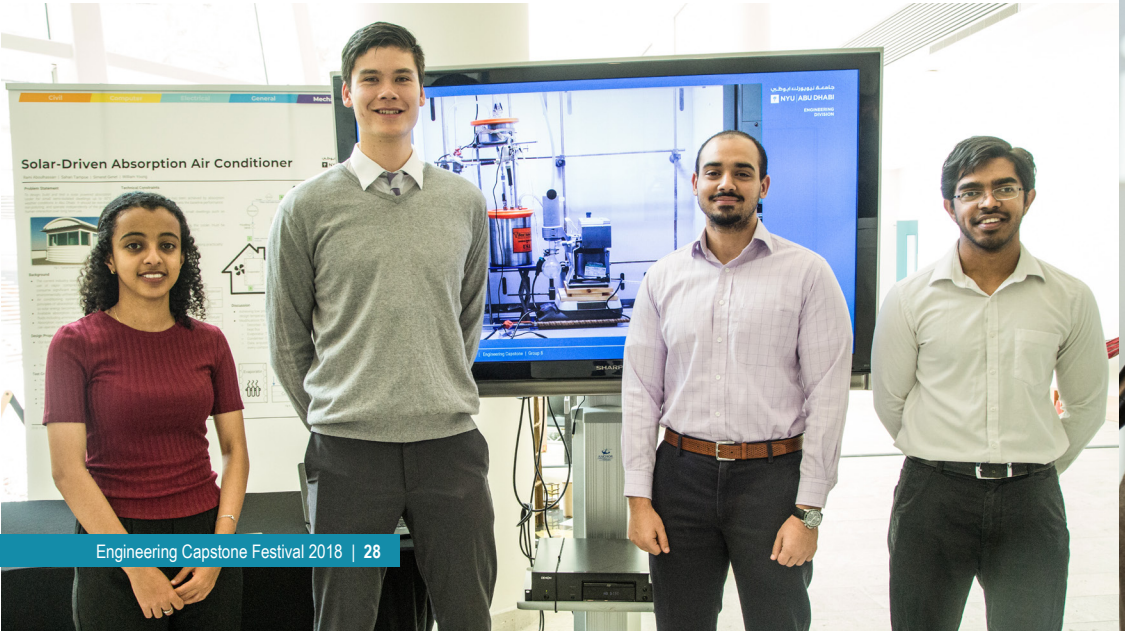
Capstone Supervisor: Mohammad Qasaimeh, Assistant Professor of Mechanical and Biomedical Engineering

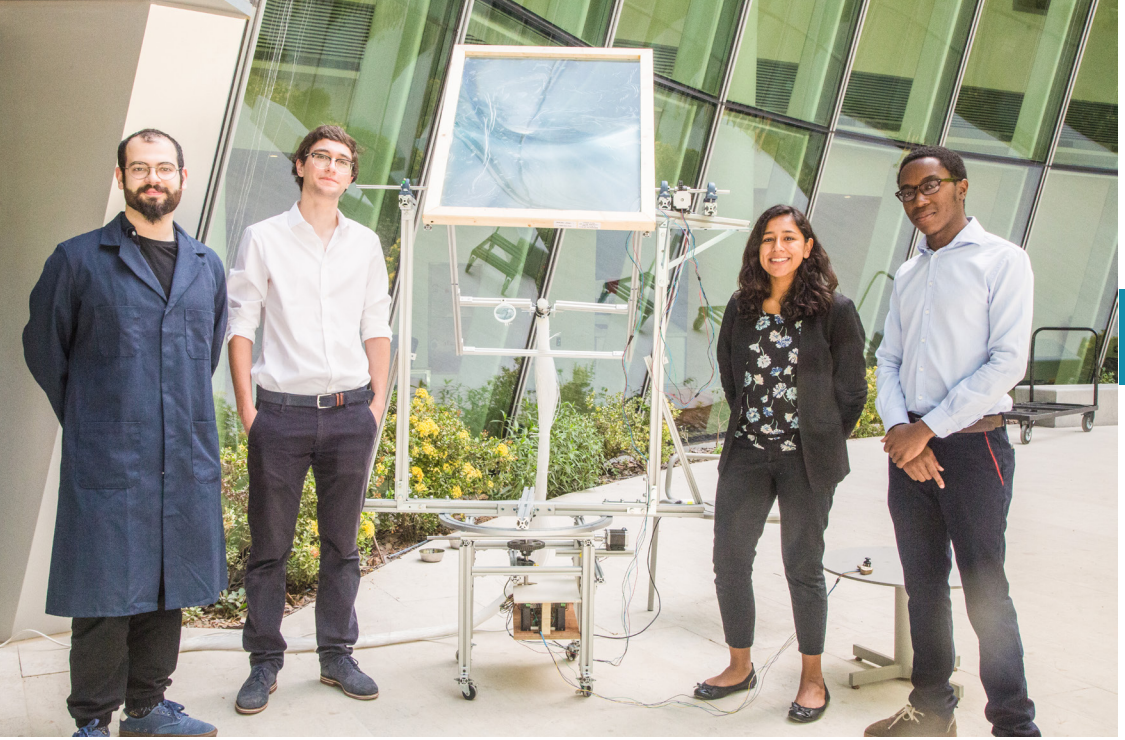
Rami Haytham Aboulhassan, Sahan S Tampoe, Simeret Genet and William Young

Solar Driven-Absorption Air Conditioning

The purpose of this capstone project was to design, build and test a single-effect absorption refrigeration cycle that uses solar energy as the sole source of energy. Design goals are focused on low toxicity, sustainability, reliability and therefore, applicability to urban environments. Conventional vapor compression cycles use electricity and emit gases that cause air pollution and therefore, there is a strong imperative to create an alternative.

Capstone Supervisor: Sachin Khapli, Assistant Professor of Engineering and Sunil Kumar, Professor of Mechanical Engineering



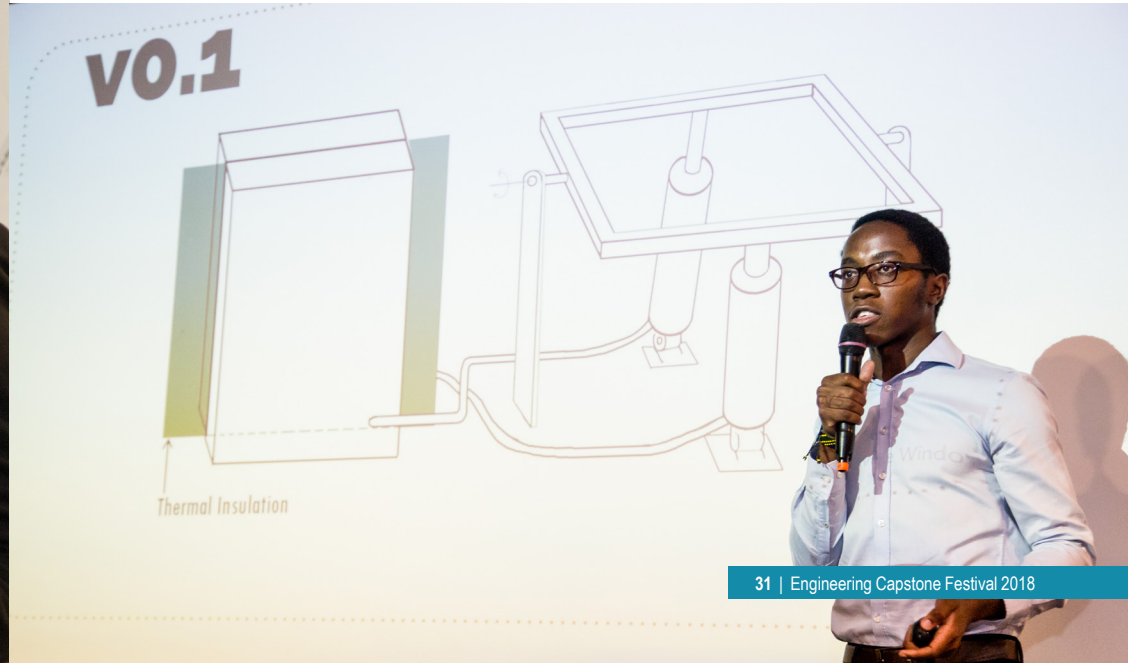


Levan Asatiani, Majed BouGhanem, Sofia Fernandez Santoyo and Yohana Mpuya

Solar Lighting

The aim of the developed device is to transport sunlight into indoor spaces using a device that is independent of the grid, not only to preserve energy for the long term but to also provide people with better quality light. The spectral composition of LED's and current indoor lighting technology is not ideal. Before the invention of artificial light technology, the only source of light eyes adapted to is the sun. Natural light stimulates essential biological functions (regulating circadian cycles), improves mood and reduces eyestrain and reduces the risk of Seasonal Affective Disorder. The light collection system proposed is a heliostat using a fresnel lens and actuated mechanically in the azimuthal and elevation angles, controlled by feedback from photosensors mounted on the lens. The actuation aims at following the sun in the sky to maximize power transmitted. The power source for actuation is designed to be an external PV panel such that the system is independent of the grid.

Capstone Supervisor: Philip Panicker, Senior Lecturer of Mechanical Engineering



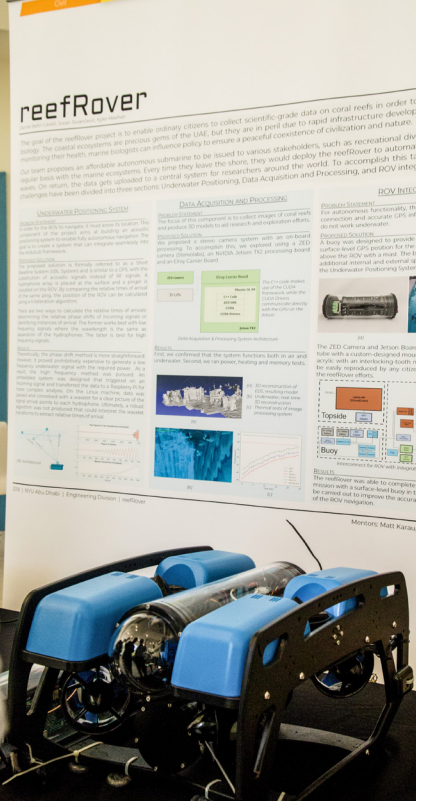
Isaiah C Mwamba, Hassan A Mahmoud, Noor E Alameri and Billy T Ben

Sustainable Low-income Housing Design

Around the world, formal housing is an increasingly scarce resource, with only the rich in society having access to it. In Africa, an estimated 60 - 70% of the population live in slums. And with the current urbanization rate, this may amount to about 1.2 billion individuals by 2050 (World Bank Group). Housing Futures estimates that the Middle East needs about 3.5 million housing units to cater for its population. The requirement for housing is especially high for low income families. The challenge thus, is finding means of alleviating this problem. In doing that, it is of the utmost importance to prioritize environmental sustainability. This project thus, seeks to address these challenges by designing a one-story house that will be environmentally sustainable, structurally durable and resilient and most importantly low cost that it should be affordable for the low-income communities.

The final design, to be made in three variants, each targeted to the Middle East, Asia and Sub- Saharan Africa will comprise of CAD drawings, computer model and design specifications. The scope of the project involves selection and testing of materials to be used in the design. The test to be conducted include the three-point flexure test, the compressive strength test, shrinkage test and thermal conductivity (insulation) test. Materials considered for this project include bamboo, timbercrete, papercrete, mycelium fibers, dessert sand bricks and triple glazed glass. Structural analysis and design will be done with SAP 2000, and in accordance with ASCE – 7 10 and IBC building codes. Additionally, the architectural design of the house will be such that it optimizes natural air circulation and illumination to reduce the energy demands of the house but should also be aesthetically pleasing and blend in with the rest of the structures around it. The timeline of the project was one semester, and the detailed breakdown vworked out using the Gantt chart and Work breakdown structure. DSM charts and critical path charts are used to manage other aspects of the project and ensure it is on track.

Capstone Supervisor: Khaled Shahin, Senior Lecturer of Civil Engineering & Engui Liu, Senior Lecturer of Civil and Environmental Engineering



Daniel Beltri Carelli, Jovan Jovančević and Kyler Meehan

reefRover

Coral reefs in the UAE are under threat of disappearing, due to rising sea temperatures. Despite the importance of studying the response of coral and marine life to the changing climate, marine researchers are not equipped with the personnel or time to survey the reefs on a large scale. Existing methods for coral monitoring are limited, compromising either on accuracy and detail, as with remote sensing, or time and efficiency of data collection, as with manta tows and SCUBA transects. The reefRover project aims to provide a solution to this problem in the form of an autonomous ROV that will perform transects along the reef and obtain high-quality images of the coral in the UAE. The ROV will be developed in a manner that enables community divers to deploy the device while ensuring data quality, and the reefRover project will be kept open-source, allowing anyone across the world to develop and deploy the reefRover and expand the available data on coral reefs. The team is divided into three main efforts -- Underwater Navigation System, Image Processing, and ROV Integration - and the vision is to have a fully operational, autonomous ROV for deployment in May 2018.

Capstone Supervisor: Matt Karau, Lecturer of Engineering Design, Antonios Tzes, Professor of Electrical and Computer Engineering and Yi Fang, Assistant Professor of Electrical and Computer Engineering

Highlights from the Capstone Festival

Highlights from the Capstone Festival

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