Downscale Design and Justification of the 2019 ATN BWSC Vehicle - (12cp)
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Supervisor: Anna Lidfors Lindqvist
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The ATN Solar Car is a new 5 state national team comprising of university students from RMIT, UTS, QUT, Uni SA & Curtin Uni, which is preparing to take on the world’s foremost and largest solar car race - the 3,000 kilometre Bridgestone World Solar Challenge

This capstone report focuses on the design and justification of a functional downscaled test model of the 2019 Australian Technology Networks (ATN) Bridgestone World Solar Car (BWSC) for the purpose of research and development in the field of scaled testing. Scaled vehicle testing is a prominent engineering challenge that many professional level motorsports teams undertake in an endeavour to improve vehicular dynamics to gain an advantage over competitors. It is intended that the use of the completed downscaled vehicle will serve as a testing and design validation platform for a PhD study, specifically testing vehicle behaviour under a range of conditions including crosswinds/aerodynamics, road surface characteristics, suspension design and weight distribution.

The downscaled vehicle is comprehensively dependent on the full-scale ATNSC vehicle in regards to geometry, weight distribution, steering and suspension attributes, requiring a complete redesign of the downscaled vehicle chassis, suspension and steering to achieve accurate 1:8 scaling properties. Model development was undertaken using SolidWorks 2016 CAD software and offered a platform to perform testing and analysis of material selection and weight distribution. The project encompasses all core mechanical systems of the full-scale vehicle and provides a comprehensive design and justification of the downscaled vehicle including scaled hardpoint geometry, parallel steering, trailing arm rear suspension and double wishbone front suspension.
Greyhounds lure mechanism has a wide variety of applications in greyhound racing in different parts of the world. It is a primary requirement for the race as the lure moves through this mechanism on the track. Current design moves on the track which has cables connected. The mechanism moves through these cables with the help of pulleys and is driven by the motor. Due to the cables, a high amount of friction is generated during the movement which causes injuries and safety issues for greyhounds as well as site members operating the race.

The purpose of this project is to investigate the problems created through the cables of the track and propose an innovative design which is a cableless lure mechanism. The idea is to modify the current design shape and change its orientation and placement on the track which is followed by a cableless mechanism so that it can reduce the number of injuries and maintain the safety and welfare standards. The research has been conducted by reviewing several Research papers regarding the Greyhound’s safety and design, a thorough study of the site design (Wentworth Park) which is then accompanied by a comprehensive Literature review.

The purpose of the cables in the current design is to drive the lure forward on the track. The motor helps to provide the required power needed to drive the cable which in turn drives the lure. By cable-less, it means that a circuitry should be embedded on the design which can control the speed, drive the system and provide backup energy to counter for extreme circumstances. In this project, Intensive research has been done on using a battery-operated lure system and using microcontrollers and charging module to run the lure through programming methods.
Flywheel Energy Storage Systems - (12cp)
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While the sun and wind are the ideal sources of energy, clean energy sources are beginning to
compete with fossil fuels. A sustainable energy plan for the future surely does not involving
depleting natural resources whilst simultaneously contributing to irreversible environmental
damages.

Clean energy can only be accumulated when the sun is shining and when the wind is blowing. The
arbitrary output of clean energy needs to be converted it into the arbitrary demand of
consumers. Fundamentally changing the electrical grid requires engineering solutions to solve the
problems associated with the intermittent nature of clean energy. This is overcome with systems
that temporarily store the energy in some form and then discharge it when the demand is greater
than supply. Unfortunately, the ideal energy storage system (ESS) does not exist, but it should
meet reasonable design specifications such as cost-effective, sustainable, compatible with the
current and future electrical grids, supports a variety of applications and long lifetime.

Flywheel energy storage system (FESS) store energy in the form of rotational kinetic energy by
rotating a body at high speeds in a vacuum enclosure supported by special bearing systems. FESS
has earned a respectable place in the market with desirable attributes such as high power density,
high energy density, instant response time and high-efficiency. The only detrimental problem is
the high self-discharge rates which is an average of 65% per day for commercial FESS; compared
to the 0.33% per day loss in the lead-acid battery. The literature does not present any practical
solution to the high self-discharge rate problem, with the bulk of the research exploring
improvements at the sub-system level especially to the rotor, with no major adaptions to the
overall configuration to overcome the high-discharge rate.

This thesis project involved innovating the conventional FESS design by re-configuring the two
main sub-systems, conducting a shape optimisation of the flywheel using the ANSYS simulation
package and construction of a proof of concept model. The design rearranges the motor/generator
unit such that the applied forces act perpendicular to the axis of rotation, which is unique among
the commercial range of FESS and the literature. The toroidal shaped flywheel levitates in a
hermetically sealed enclosure. The flywheel motion is constrained by a 5 DOF control system
which uses a Halbach array and electromagnets. The flywheel accelerates when the DC supply
passes through the stator winding to produce a magnetic field that interacts with the permanent
magnets embedded in the flywheel body. The stored kinetic energy is converted back to electricity
by an induced emf in the stator coil.

The innovative design offers superior magnetic field interaction between the flywheel and stator.
The distance between the stator coil and permanent magnets is reduced and the force applied more
uniformly to the flywheel body. Not all the losses are avoided or mitigated, however this design
can serve as the basis for developing a prototype.
Design of Small Aperture Mains Inspection Robot - (12cp)
Riccardo Rossi - S18-120

Supervisor: Professor Gamini Dissanayake
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

The cast iron pipes of Sydney Water’s water distribution network have been in commission for approximately 100 years in some areas. Consequently, some of these pipes have corroded and are prone to failure. The ability to locate potentially weak sections of the critical pipe network and conduct a planned replacement with minimal disruption to customers is therefore important to Sydney Water. UTS Centre for Autonomous Systems (UTS CAS) is currently contracted to research and develop the sensing technology to measure the pipe wall thickness of the cast iron pipes and incorporate these sensors into two robotic tools that can be deployed to examine the pipes during a short window between a pipe break and its repair, and during planned maintenance exercises.

The two robotic tools that have been developed and are currently used for condition assessments are only suitable for relatively straight section of the network and for pipes with diameters above 350mm in diameter. The focus of this project is to develop a new design that is able to negotiate up to 90-degree bends and suitable for use with 200mm diameter pipes. This required developing new concepts for both sensing and locomotion. Unlike the existing devices, locomotion and sensing has been successfully decoupled so that the effective length of the device is reduced making it possible to negotiate bends. The sensing mechanism is redesigned to enable self-centering without the aid of any lifting mechanisms and able to deal with smaller diameter pipes.
Robotics technology is transforming our daily lives in a variety of new markets and social aspects. The technology is being applied for disaster response, health care, domestic tasks, transport, space, manufacturing, and construction.

The Mohamed Bin Zayed International Robotics Challenge (MBZIRC) is a biennial international robotics competition. The competition goal is to inspire the development of the robotics industry through innovative solutions and technological excellence. The second challenge in the competition consists of path planning, manipulation, perception and 3D printing tasks for both Unmanned Ground Vehicle (UGV) and Unmanned Air Vehicle (UAV). All tasks need to be done automatically and all participating vehicles need to be synchronized.

This report describes the development of my capstone project throughout my final year. The initial research proposal was to design an algorithm to help navigate the mobile base and explore the environment during the second challenge of the MBZIRC competition. In order to achieve the requirements, it was necessary to combine the ROS navigation stack and frontier exploration packages.

After completed the navigation and exploration algorithm, the next challenge was the perception tasks of the MBZIRC second challenge. There are two tasks: to locate brick piles and to find an individual brick within a brick pile. A Realsense D435 camera was used for these tasks. For the first task, OpenCV blob detection and color detection were utilized to locate the brick piles. For the latter, the method is to do plane segmentation to separate planes within the camera's field of view and then compare these planes to the geometry characteristic of the bricks, which are specified by the competition organizer.

All algorithms were experimentally verified for simulations after 6 months of development. Furthermore, path planning and perception algorithms have been successfully tested on a real robot platform. On the other hand, Exploration algorithm is waiting to be tested on the mobile platform. These algorithms are later to be combined and integrated with a larger team’s work towards the MBZIRC competition.
Force-Torque Control for Surface Treatment with a Robotic Manipulator Arm - (12cp)
Luke Ramos - S18-087

Supervisor: Dr Jaime Valls Miro
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

Surface treatment (e.g. polishing, grinding and de-burring etc.) has often been a task performed by a human worker. It is especially important in manufacturing industries where surface finish is part of customer satisfaction or design requirements, such as the automotive industry. Human error is inherent in any process that involves a human worker. The repeatability, reliability and consistency of surface treatment from a human worker can vary drastically and is affected by many factors. As a result, the variance in surface treatment performed by a human worker could yield varying costs to manufacturers, customers and other respective industries. My research aims to provide a means to improve repeatability, reliability and consistency of surface treatment with the use of a robotic manipulator arm.

The focus of my research explores calculating and applying a desired force to a treatment surface. Initially, methods of force control with a robotic manipulator arm involved the use of a force-torque sensor on the end-effector of the robotic arm. Sliding-Mode Control is one such example that relies on the use of a force-torque sensor and works within the velocity-level of robotic control. Later, novel methods were investigated with the aim to eliminate the need for the force-torque sensor by exploiting torque control techniques. This calculates predictive joint torques to yield a desired wrench (force and torque) at the end-effector of the robot.
Vibration suppression is an integral part of the preliminary aircraft design process where the aeroelastic stability of a system is determined and optimised leading to an increasingly higher-performing aircraft. As the flight envelope is pushed further, innovations within the aerospace industry are continuing to yield lighter, slender and more flexible aircraft. As a result, modern aircraft are now becoming increasingly susceptible to a catastrophic aeroelastic phenomenon known as flutter. Flutter is an unstable self-excited oscillation resulting in structural failure.

Through research and analysis of existing literature, it was evident that there was a significant amount of information relating to the historical development and advancement of vibration suppression utilised in aeroelastic stability. Current academic research focuses heavily on active methods of control, where closed loop control surfaces alter the aerodynamic response of the aircraft. This shift of focus has left a significant gap in literature for further research and investigation into passive vibration suppression. The aim of this thesis is to address the vacancy in literature and provide a scope for future work.

This research project will provide a theoretical background of the fundamental concepts and significant developments that have shaped aeroelasticity from an engineering perspective. The objective and primary emphasis of this paper is passive vibration suppression and stability analysis examined by a comprehensive academic literature review. This review will draw on relevant methodologies and experimental results of existing work aimed at enhancing the performance of the aircraft by passively suppressing flutter.
Additive manufacturing has proven to be more resource and energy efficient while still maintaining the high quality that is required of parts. Due to this, the industry has undergone unprecedented expansion over the last decade. Projections have shown that the industry’s value is expected to multiply due to increasing demand. Despite this, pessimistic forecasters convey that much of the potential within the additive manufacturing industry will be difficult to attain. Therefore, significant research needs to be done to realise the potential benefits that are expected of the manufacturing process.

One large hurdle is an increase in waste due to the larger market. This not only results in large economic impacts on the company, but also degradation of the environment with excessive waste. Due to this, companies that can effectively recycle their materials or utilise fully and partially recycled materials will gain a competitive advantage. Therefore, material recovery pathways were analysed in order to identify the range of options to recycle and reutilise the additive manufacturing waste.

This research analyses the recovery processes that are currently available for PLA. Each of the methods is assessed through economic, social and environmental lenses to understand the triple bottom line impacts and provide a trade-off list for industry. Ideally this research will allow companies to utilise the assessment to select the process which is most appropriate for them.
Development of an Amphibious Autonomous Underwater Vehicle (AUV) for the Surf Zone - (12cp)
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Supervisor: Dr Marc Carmichael
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

Commercial, scientific and military applications exist where robots are required to navigate and traverse amphibiously in the surf zone. This poses unique challenges such as surviving the extreme corrosive environment, battling against the chaotic flow, and finding a suitable locomotive system that is effective in water and on land. Combatting these challenges, the sophistication of current commercial autonomous vehicles means that organisations are often impeded by the financial investment to acquire these vehicles in exploring new applications in the surf zone. The ability to access low-cost, robust amphibious vehicles would pave the way for a new generation of innovation and invention in the surf zone.

In this paper I explore the original design of a 1-man portable and operable, amphibious autonomous underwater vehicle (AUV) system to serve as a platform to carry a multitude of payloads. The system is built using commercial off the shelf (COTS) products and comprises of a bottom-crawling amphibious AUV and a hand-held CommsBox. The CommsBox is the translator between the operator and the AUV, and interfaces with any standard mobile, tablet or laptop via WiFi. The AUV itself features an internal sensor suite including GPS, a 9-DOF IMU, temperature & humidity sensors, water ingress sensors, a battery voltage sensor and wheel encoders. Moreover aspects such as assembly, maintenance, and user operability have been kept at the forefront of the design.

The financial cost to develop the whole AUV system totals to under $2500, and the internal sensory suite of the AUV is sufficient to support its autonomous capabilities as well as monitor the vehicle’s status. As a first design revision, this build delivers a low-cost, effective amphibious vehicle platform. Through the development of this system, current technological limitations are identified and recommendations for future work are presented.
Assessment of Infection Control & Operating Theatre Practices in HVAC&R and Proposition of New Standards and Design Characteristics - (12cp)
Frazer Caswell - S18-034

Supervisor: Dr Saidul Islam
Major: Mechanical Engineering Major BEBBus and BEBSc

According to the Australian Commission on Safety and Quality in Health Care, approximately 5600 surgical site infections (SSIs) occurred in Australian operating rooms (ORs) during 2015-2016. The incidence of each SSI cost $42,000 on average to treat, including 20.3 additional days of patient hospitalization. Breakthrough investigations of over 8000 surgeries have revealed a strong relationship between rate of SSI occurrence and the indoor air quality (IAQ) of the OR. Hence, the mechanical services or HVAC&R system controlling IAQ in the OR are also strongly implicated in the incidence of SSIs.

Unfortunately, due to the limited design guidance currently offered in Australia, many mechanical design engineers are left to consult a variety of International Standards and design guidelines, with each providing differing approaches to both design and the required conditions. There is no current and consistent Australian Standard around the required internal conditions of OR’s nor the design of appropriate OR ventilation systems. Any published guidance has largely been done at State or territory level resulting in a lack of industry-wide consistency or standardization in the design of operating room HVAC&R systems.

This capstone seeks to research and analyze the differences between a variety of International Standards and design guidelines commonly consulted by Australian engineers. The objective of this comparison is to determine, from the research available, which factors have the greatest effect on IAQ in the operating room and what the best practice approach to OR design looks like when considering these factors.

Best practice design will be identified by reviewing relevant literature, mostly composed of scientific studies which analyze the efficacy of different OR designs by using methods such as computational fluid dynamics or bacterial count sampling. The studies included in this thesis will be those that can be related to the investigated International Standards and design guidelines.
Design and Simulation of an in-Wheel Permanent Magnet Electric Motor for Direct Vehicular Drive - (12cp)
Nabin Sapkota - S18-115

Supervisor: Dr Ha Pham
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With the recent propagation and innovation behind the concept of electric vehicles (EVs), new and interesting ideas are emerging to further improve on the idea and provide better alternatives to current technologies. At present, the main type of transmission that is widely accepted employs a main motor geared to a shaft that delivers the power to the wheels.

The main industry fears relating to in-wheel drive has been the increase in the overall un-sprung mass (total mass supported by the suspension) and whether the configuration of heavy motors exacerbates the performance and efficiency. A study supported by Lotus Engineering which tested the veracity of these claims concluded that they were only hearsay and that the addition of one or more typically weighing motor directly did not have a significant impact on the performance (Dynamics of Vehicles with in-wheel Motors, 2011).

It is becoming clearer now that an in-wheel direct drive is a viable choice which offers different advantages that would be beneficial on a wider scale. These advantages include the simplicity of hub motor application, their compactness and elimination for the need for heavy transmission, differential and axles altogether. This reduces the mechanical losses and the drive is overall more efficient from various aspects of design. Also, with motor control, it is also possible to fine tune each motor to vary the torques, rpms and even direction of spin all through a master control.

Noting these advantages, my study aims to show the concept through design choices that reflect design criteria from the UTS:Electric Motorsport team to put into context. Simulations tested includes ANSYS RMXprt design culminating to a final transient analysis using 2D and 3D Maxwell Electronics Desktop simulations. These values were then used and then exported to produce a 3D CAD model on SolidWorks demonstrating the proof of concept and providing a physical demonstration of the model. Design choices and final motor assembly is also investigated that employs fundamental Mechanical Engineering Principles.
As we move further into the future driverless vehicles will be part of society, which has resulted in several formula student competitions such as Formula Student Germany(FSG) and Formula SAE Australasia to introduce a new category for autonomous racing. For 2019 the plan for the UTS motorsport autonomous team is to convert the 2017 FSAE vehicle to have driverless capabilities.

This capstone project aimed to firstly incorporate several electromechanical systems to actuate the steering and braking. Secondly, create a CAN bus system to allow an NVIDIA Jetson TX2 to control the vehicle. Thirdly modify the current CAN (controller area network) bus system to control the acceleration of the car. Finally, to incorporate ROS (Robotic Operating System) to the control system and allow the team to connect sensors and path planning algorithms for full autonomous controllability.

The design of the steering, acceleration and braking was developed to be overridable which meant that a driver was able to take control of the vehicle when the autonomous mode was turned off. The systems were also designed to fit in the chassis of the 2017 FSAE vehicle and allow the driver to fit without any obstructions. The steering and braking had to incorporate a closed loop control system for which the Proportional, Integral, Derivative (PID) gains were tunable to allow for optimal response. Several of the Mechanical componentry had to be FEA (Finite Element Analysis) tested to analyse the structural effects of the dynamic loads on them.

This project was tested at the Sydney Motorsport Park Figure Eight skid circuit where we remotely tested the control system for acceleration, steering and cornering. The test showed positive results in terms of functionality, controllability and reliability. We were also able to get a significant amount of data for analysis and understood areas where we could improve further.
Investigating the Variable Damping Requirements for a Multi-Purpose Van - (12cp)
Andrew Schaap - S18-134

Supervisor: Dr Paul Walker
Major: Mechanical Engineering Major BE and BEDipEngPrac

Light commercial vehicles, such as medium-sized vans, are designed to be driven in a number of different operating conditions; caused by varying occupant numbers, cargo loads and towing applications. These changing conditions inherently effect the dynamic characteristics of the vehicle, including the ride and handling which are directly transmitted to the occupant. A dominant factor in the quality of ride and handling is the suspension damping, which, on most commercial vehicles currently on the market, is a passive system only optimised for a single operating condition. Active damping presents an opportunity to maintain a quality of ride and handling regardless of the condition, thus the viability of incorporating this technology in a light commercial vehicle is tested and validated.

The variable damping requirements for a specific vehicle are investigated in this report. Half-car models were used to analyse the vibration response in three different cases – unloaded, loaded and towing. For each case a desirable damping rate was determined which defined the range which the dampers needed to offer. These requirements along with dimensional information of the factory damper units were supplied to Tractive Suspension in Holland, who manufactured the new suspension units that were then fitted to the vehicle. Data collected from the vehicle using rotary potentiometers provided a platform for comparison between the two damper types, with the results showing the improvements the variable damping had on the measurable metrics in all conditions. These results prove the viability of active damping technology when applied to a light commercial vehicle, presenting opportunities to improve the ride and handling given any operating condition.
The Circular Economy in Relation to Office Fitouts - (12cp)
Lorna Hennessy - SU18-011

Supervisor: Professor Sara Wilkinson
Major: Mechanical Engineering Major BE and BEDipEngPra

In Sydney’s Central Business District, 400,000m² of commercial office space is refurbished each year. The stripout works associated with a refurbishment generate 63 tonnes of material per 1000m², meaning that 25,000 tonnes of material are generated annually from the fitout industry alone. Of this material, 79% of it ends up in landfill, which is well below the 64% recycling rate of the construction industry Australia wide.

In a Sydney property market characterized by low vacancies and high rental values, the average duration of a lease for a premium office is 7 years (Property Council of Australia A Grade or above). This high churn rate and typically stringent make good clauses result in a large amount of unnecessary waste where office furniture, and services such as lighting and air-conditioning equipment are removed long before the end of their effective life. Compounding this is our limited ability to recycle treated timber and tight stripout time frames which result in poor separation of waste and recycling streams. This results in a low landfill diversion rate and a negative social and environmental impact.

This capstone project explores the role of different stakeholders in the office fitout industry and changes that can be made to reduce the amount of waste associated with stripouts. It will investigate the role of the circular economy and how collaboration of stakeholders can have a positive social and environmental impact.
Visual Docking for Drink delivery - (12cp)
Billy Anthony - S18-147

Supervisor: Dr Teresa Vidal Calleja
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

Autonomous indoor delivery is becoming increasingly popular to enhance productivity in warehouses, hospitals, hotels and now even offices. UTS:CAS is collaborating with PwC to develop a robot that autonomously delivers drinks from a vending machine to desks. This capstone project directly contributes to this collaboration.

The aim of this project is to develop a visual docking algorithm that allows a mobile robot to be accurately positioned to pick drinks from a vending machine. Furthermore, the algorithm has to be integrated with robot navigation and delivering approach.

The position based visual servoing system uses AR track Alvar algorithm to detect AR tag and estimate the 3D pose of the robot from the camera. Robot docking algorithm is executed by calculating the error from the robot current pose to the desired position. Lidar is further utilised to drive the robot closer to the vending machine due to robot losing sight of the AR tag while it is driving closer. Losing sight of AR tag occurred due to robot limited field of view and robot nonholonomic property.

A Kalman filter is added on the visual docking algorithm to increase the accuracy of robot pose and predicts robot next pose based on robot previous velocity, pose, and angular velocity. The robot also benefits from the Kalman filter by keeping track robot pose even though losing sight of the AR tag that provides most of the information needed to perform visual docking.

The drawback of implementing visual docking system in the nonholonomic robot is the limitation of robot movement to keep an AR tag within the robot field of view. This problem has been addressed by integrating the Kalman filter and robot navigation stack, which help the robot to localize itself within the map and drive it towards the desired position while losing sight of the AR tag.

The approach has been tested extensively and guarantees that the initial orientation is within a few degrees error. Moreover, this error is corrected by the line extraction algorithm obtained by the lidar, guaranteeing consistently successful docking.
Manipulation and Perception Algorithms for Mbzirc 2020 Autonomous Ground Vehicle - (12cp)
Simon Fryc - S18-014

Supervisor: Dr Teresa Vidal Calleja
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

The University of Technology Sydney has been invited to compete in the 2020 Mohamed Bin Zayed International Robotics Challenge (MBZIRC). The competition presents a set of technologically demanding challenges focused on robotics and automation. Although a lot of progress has been made towards the development of autonomous robots in recent years, it remains highly desirable to research and develop robots that can intercommunicate and work autonomously in dynamic environments such as the outdoors. Enabling robots to perceive their environment and cooperate independently presents new opportunities for research in a range of robotic swarm applications including disaster response, transportation, manufacturing, and construction.

This capstone project is part of a collaborative effort that aims to develop a mobile robot that can autonomously locate, pick, transport and assemble different types of brick-shaped objects to build a predefined structure. The research presented here focuses on the creation of a simulated manipulator model that was used to develop control and perception algorithms. These algorithms enabled the robot to autonomously pick and place objects while maintaining an awareness of its environment for collision detection and avoidance. Perception was incorporated into the system using a customised implementation of the OctoMap 3D mapping framework. A pick and place pipeline was demonstrated using a suite of 3D cameras and a mobile industrial manipulator. Intrinsic and extrinsic calibration routines were performed to ensure the highest level of sensor and manipulator accuracy. A novel gripping mechanism was also designed to evaluate the use of an electro-permanent magnet for picking and placing non-permanent ferromagnetic objects.

The research discusses the effectiveness of developing and testing robotic algorithms in a physics simulator and articulates the challenges of transitioning from simulation to reality. The robot was capable of completing all the stated objectives with a high level of autonomy using these methods. However, the system would benefit from further research into the communication protocols necessary for sharing intelligence and coordinating actions between individual robots, thereby increasing their effectiveness and value to society.
Sustainably Designed Speaker - (12cp)
Alon Cohen - S18-300

Supervisor: Dr Alan Sixsmith
Major: Mechanical Engineering Major BE and BEDipEngPrac

This report is about the design of a sustainable speaker that aims to combat the global problem of E-waste. By educating people about consumer electronics and the serious problems created by electronic waste on the planet, I am then able to powerfully market my design of a sustainable speaker that aims to fight the problem of consumer electronics and E-waste. Whilst also providing a new product, made from a mix of new and recycled parts that are designed to be repairable and serviceable in an aesthetically pleasing package that in itself is a timeless piece of art capable of being cherished and used by my customers for many years. Eliminating the need to dispose of electronic goods prematurely for want of the latest design or minor faults. Thereby adhering to the three principles of sustainability, reduce, reuse, and recycle.

All of the research, design and construction of prototypes for this report was carried out by myself, with the guidance of my Professor Alan Sixsmith, the support and patience of my girlfriend in living amongst the many speakers and suitcases in our house (without ever actually going on holiday), the support of my close friends who encouraged me to persevere and my initial customers who purchased my speakers with confidence in my speaker building abilities and environmental motivations to improve the world.

They key components of this report include background research into the problem of E-waste and recycling, my design solution, build process and methodology which also includes a special Video explaining the concept of my business and process of building speakers, marketing and legal research into setting up a small business in Sweden and a completed and functional prototype speaker for demonstration.

Through this report and process I have found myself many new opportunities for growth and development, as an engineer and designer. Through which I hope many doors will open in the future, as I persevere and continue to develop my design and business well into the future past graduation.
Feasibility and Testing of On-Board Waste Vegetable Oil Processing for Petro-Diesel Powered Car - (12cp)  
Solomon Ould - S18-171

Supervisor: Dr Terry Brown  
Major: Mechanical Engineering Major BE and BEDipEngPrac

There is growing social pressure toward finding renewable energy sources and reducing the impacts of climate change. In the context of light vehicles this agenda has resulted in a move away from fossil fuel powered engines. Whilst electric cars are an integral future step in order to reduce greenhouse gas emissions, there is still a current requirement to provide liquid fuels for vehicles and equipment currently in operation.

The main objective of this paper is to design, and review the build, of a prototype system which will allow waste vegetable oil (“WVO”) from commercial businesses to directly fuel a traditional Petro-Diesel vehicle. The prototype system achieves this without the inefficient step of external processing of the fuel. Prior ad-hoc designs of similar systems have been attempted in the past with varying of levels of success. The paper describes the scientific testing, and engineering design principles used, to extend the functionality and quality of the final system above that of previous attempts found in literature.

Investigations into the history and literature on WVO conversions, advantages and disadvantages of prior systems, energy density testing and rheological analysis of WVO and Petro-Diesel are completed. The selection of critical system components, manufacturing processes used in the development of the prototype system, and practicality of the final product are assessed.

While the final prototype system uses a novel design, and the vehicle is successfully powered using WVO processed on-board, there are a number of drawbacks to the final prototype system which are discussed. There exist many areas for continued development and testing of the system into the future.
Intelligent Thruster for Underwater Analysis - (12cp)
Timothy Zalloua - S18-121

Supervisor: Dr Zenon Chaczko
Major: Mechanical and Mechatronic Engineering Major BE and BEDipEngPrac

The Internet of Things (IOT) is a modern concept used to describe the interconnection between various devices through the internet. These devices send and receive data; which can then be analysed and subsequent actions can be taken. There are several IOT based solutions currently available in the underwater systems field. These devices primarily appear in the form of remotely operated underwater vehicles (ROVs). They can collect a variety of metrics from environments that humans either cannot reach, or cannot maintain a presence in.

An ROV is primarily made up of several thrusters, along with a central hub that houses system components. There are a variety of components that make an ROV intelligent, this includes a wide array of sensors along with a processing system to interpret the data and a communications system to transmit said data to the user. Taking these components and applying them to the thruster itself allows for an innovative solution that further enhances the customization and application possibilities of an ROV. An Intelligent Thruster could be mounted to a variety of vehicles, components or even humans for underwater exploration, providing useful data in the form of temperature, acceleration and positioning, along with a visual representation of the surroundings as well as the state/health of the thruster itself. With this level of visualization, a user has not only a modular device, but also a clear understanding of the state of their overall system, allowing them to proactively act on any device related faults or failures before they occur. Furthermore, the aquadynamic design and unique characteristics of the propeller provide a safer device for human interaction as well as the environment.

This project will act as a proof of concept for how a thruster can be home to a livestreaming camera unit and an acceleration and orientation sensor while maintaining an aquadynamic design with appropriate propeller thrust. The propeller will be selected based on preliminary testing and experimentation involving a variety of different shaped propellers. An interactive user interface will be implemented for control of the thruster. The solution will be implemented on a testbed in order to demonstrate a variety of future applications for the device.
Bloodbook - (12cp)
Parth Saija - SU18-020
Supervisor: Dr Zenon Chaczko
Major: ICT Engineering major BE(Hons), BE(Hons) DipProfEngPrac

Blood donation currently is a major issue all over the world. There are lot of campaigns, government or non-government organizations and camps which are trying their best to increase awareness and make people understand how important it is to donate blood. Lot of lives can be saved by only donating a little bit of blood. Currently lot of countries and startup businesses are trying to make a software where they can assemble everything in one web service or application but still these are not accomplished or not been used yet.

Lack in blood donors is not because the world does not have enough donors, it is because there is a lack of communication, awareness and safety. Blood is not an amenity which can be sold or bought. It must donate by understanding the need of the ones who can die without it. Anyone in the world living in any country can face the situation of a disease, accident or lack of blood and could be at a risk of death who can only live by accepting blood from a donor. Also, lot of people think that they are not healthy enough to donate blood. So, bloodbook will be integrated with the fitness app known as strava which is a popular application can be used to connect, compete and be fit by cycling, running and exercising.

Bloodbook will provide features like searching for the donors, looking up for donation centers, connecting with friends, viewing posts from camps, campaigns, hospitals, government or non-government organizations and friends. These posts will spread awareness and can make people care about not blood donation but also their own fitness. Users will get a dashboard where they can view their own activities and keep a track of their blood donation dates and places.
Remotely Piloted Aircraft (RPA) or RPA legislation and control has become a rising issue with the increasing trend of recreational RPA and commercial RPA use. There are several risks that are posed by unregulated and uncontrolled RPAs a major one including impact with a manned aircraft which could lead to catastrophic failure and a loss of life. In this space another area that has been underdeveloped is complex mission planning and simulation. In dense and complex environment with many factors that may affect a mission it's hard to appropriately plan a complex mission such as Search and Rescue Operations and package deliveries in high obstacle areas like dense cities. It is not practical or possible to plan with in these scenarios especially in situations where the RPA operator (planner) is not at the physical location. 

This project in a partnership with Thales Australia explores how the use of a virtual reality environment can assist in drone operation planning, management. This is further expanded with a virtual environment of Sydney to simulate and evaluate drone operations. 

Drone operation planning and authorisation in airspaces is a major step forward for responsible regulation of drones. This is an integral feature of this capstone which allows drone operators to plan complex missions and view airspace restrictions in a virtual environment. The use of a virtual environment allows operators to plan their flight down to meters and submit it for authorisation to fly later. Additionally this solution provides the ability to simulate a drone operation to evaluate its performance and any environmental hazards it may encounter. These two features form a basis for a flexible and extendable virtual reality drone playground to quickly and iteratively test drone operations and simulate them. The solution can be easily extended for different environments and simulated AR capability.
Traffic Scene Understanding - (12cp)
Zezheng Zhao - S18-175

Supervisor: Dr Jun Li
Major: ICT Engineering major BE(Hons), BE(Hons) DipProfEngPrac

In recent times, scene understanding holds a significant position in computer vision due to its real-time perceiving, analysing and elaborating an interpretation of dynamic scene which leads to new discoveries. Scene understanding is an important prerequisite for autonomous driving. With the development and innovation of the automotive industry, people’s demand for safe travel has increased and the auto-driving technology is better in the fields of reaction speed, accurately and risk control compares to manual driving. One challenge of developing AI systems to analyse traffic scenes is the lack of data. There are few practical datasets, such as KITTI, but the number of samples is limited. More importantly, the archived datasets generally do not allow users to interact with the scene and explore different consequences caused by various decisions. The main aim of this project is to build a real-time image/video analysis tools on a simulated environment (traffic scene), which then allows further experiments.

To implement these objects, the primary technologies I used are Python, convolutional neural network, YOLOv3 algorithms, End-to-End lane Detection, SFM-net, TensorFlow etc. The major process of this project is collecting and normalising data from video game (GTAV), establishing and training a neural network, get the loss function’s value and try to develop a robust neural network via tuning the parameter.

There are three major functions in this scene understanding tool: 1. Detect objects of interest in the image (such as the guidepost, pedestrians, vehicles Because this image analyse tool is used for traffic scene analysis) 2. Implement a deep neural network for real-time lane detection based on the segmentation approach.3. Track the object and learning of structure and motion from traffic scene video.
Indoor Navigation in Multi-Level Building - (12cp)
Xuhan Zuo - S18-177

Supervisor: Dr Cat Kutay
Major: ICT Engineering major BE(Hons), BE(Hons) DipProfEngPrac

Due to the occlusion of satellite signals with a varied and complicated indoor environment, this navigation method cannot be applied to indoor areas. However, problems such as underground parking garage route planning, shopping mall guidance, fire rescue, etc., should be solved in indoor scenes, promoting the development of indoor navigation technology. In that case, how to achieve reliable indoor multilevel navigation has become a hot and critical topic in recent research. Due to the influence of indoor multipath propagation and non-line-of-sight propagation, the navigation accuracy of A-GPS positioning technology and ZigBee positioning technology is severely degraded. Wi-Fi positioning technology and Bluetooth positioning technology can overcome the impact of non-line-of-sight propagation (Li et al., 2018). Many building rooms have Wi-Fi hotspots that can be located without additional equipment, however Bluetooth positioning requires beacons. This project focuses on WIFI positioning and indoor navigation. The Bluetooth positioning as an optional approach for further research, because of the limitation of the demonstration building.

This project can provide mobile APP for UTS CB11 Level 2 and 3 to demonstrate technologies which can test the feasibility of this system in industry. The RSSI-based positioning algorithm uses three-pass measurement to measure the distance. Dijkstra algorithm can find both the undirected graph and the shortest path of the directed graph. Also, this project will show the result of using RSS to perform indoor positioning simulation experiments. The whole process will be supported by Firebase cloud data and provide the design of the software architectures for such a system. The indoor map resource is built by ArcGIS for this project. Also the project will provide the analysis of this approach in commercial fields, showing the ability to use API from IoT such as heating sensors. This project aims this system can apply indoor navigation technology to observe the status of the user in the building and provide guidance in real time.
Development of an Ontology for Multi-Level Indoor Navigation - (12cp)
Ye Yuan - S18-174

Supervisor: Dr Xiaoying Kong
Major: ICT Engineering major BE(Hons), BE(Hons) DipProfEngPrac

About 90 per cent of human activities is in indoor environments. A need for indoor navigation requires Location-Based Services (LBS), which could help people find the best route inside a building under circumstances and with high reliability.

The current research has been focusing on technologies and applications for LBS. Based on some previous researches, a revised ontology for multi-level indoor navigation has been developed. This ontology is going to create clear models (Building, Level, Link, Zone and Node) to store data and indicate the connections between them. A complex process for multi-level indoor navigation will be simplified to specific understandable processes: navigation from start node to the nearest link node (lift or stair), navigation from link node in target level to the end node. The nodes including location information allow navigations at the same level, then links (the model for connecting different levels) will lead the navigation from start level to the target level.

For testing the feasibility, a static model for UTS Building 11 was created, which will be used in an application. This application will display the basic simulations for the navigation process which happen between Level 8 and Level 9.

Key Words: Indoor Navigation, Indoor Space, Indoor Ontology, Location-based Services, Database.
Cancer is one of the major causes of the death worldwide, with lung cancer being the most common malignancy with an estimated 1.6 million new cases every year. Globally, 10% to 15% of all diagnosed lung cancer cases are small-cell lung cancer (SCLC), and despite the application of conventional cytotoxic chemotherapy and radiation therapy, the patient’s outlook remains bleak with a 5-year survival rate of 1-2%. Conventional chemotherapy lacks specificity, with currently applied drug delivery systems remaining suboptimal. This is due to the highly toxic nature of anticancer agents which limit their treatment use in optimal concentrations, with high doses having adverse side effects on the patient’s body. Thus, there is an urgent need for therapeutics that can specifically target the cancer cells.

EnGeneIC's bacterially-derived EDVTM provides a safe and highly targeted mode of transport using bispecific antibodies, to deliver a highly toxic payload, whilst simultaneously stimulating the immune response which thereby increases the body's anti-tumour response. EDVTM nanocells are coated with lipopolysaccharides (LPS) which activate the immune response. However, for direct access to the cancer cell it requires a targeting antibody that is specific only to SCLC and not present on healthy cells. The EDVTM has the ability to load up to one million drug molecules and deliver intracellularly to the targeted cell environment.

This project aims to make a bispecific antibody (combine specificities of two antibodies and simultaneously address different antigens) against a common receptor(s) on SCLC in the single-chain variable fragment (scFv) format. In the lab, we employed genetic engineering to produce a large quantity of such antibody and purified it from bacteria. After the production and purification of the bispecific antibody, it was then attached to an EDVTM nanocell to generate a delivery vehicle that could target a SCLC cell specific receptor in-vitro, which will then be able to deliver a toxic payload directly to the site of the tumour.
Producing 3D Printed Polymer Constructs to Utilise Mechanotransduction for Bone or Cartilage Regeneration - (12cp)
Carin Basirun - S18-058

Supervisor: Dr Jerran Santos
Major: Biomedical Engineering

There is an aging global population, as such there is a cumulative issue of bone disorders. Furthermore, the increasing demand for the development of treatments of diseases related to the musculoskeletal system. As part of the musculoskeletal system, bone is responsible for mechanical support for the soft tissues and muscles, including providing support for body shape and movement. With continuous pressure and high impacts, the ability of bone to tolerate strength decreases, causing a fracture. Although bone has the ability to self-heal, this is not the case with large-scale bone defects or trauma. In this case, the bone defects cannot be entirely healed by the body, and other intervention and treatment are required to have a functional bone.

Bone tissue engineering is an exciting field that focus on developing the bone tissue environment using a scaffold. In 2013, Bose, Vahabzadeh and Bandyopadhyay have noted that 3D printing has become a popular method for making scaffolds for bone tissue engineering. It is a versatile tool that can fabricate scaffolds with defined shapes as well as with controlled and interconnected porous structures.

The purpose of this research is to produce 3D printed polymer constructs using Polylactic acid (PLA) and use the mechano transduction properties for bone or cartilage regeneration. Parameters such as geometrical shape, pore size and scaffold architecture were varied and tested. Production of the scaffolds were done using Makerbot Replicator +, using the same print settings. This printing process eliminated several structures to be mechanically and biologically tested. Mechanical test of the various scaffolds was completed to analyse and compare the compression, impact and tensile strength to biological bone. The biological results of the successful prints have shown that the various scaffolds structures had an impact in the attachment of cells to the PLA over the course of 7 days and 14 days.
Development of an Illumination System for a Smartphone-Based Retinal Oximeter -
(12cp)
Connie Land - S18-113

Supervisor: Professor John Canning
Major: 120cp Biomedical Engineering major BE, BE DipEngPrac

The retina is one of the most metabolically active tissues within the human body. It expends oxygen faster than the brain hailing it a valuable outlook into the body’s circulatory system and its health. Our understanding of retinal diseases has only recently been made possible through the pioneering studies and development of imaging modalities that have provided insight into the relationship between retinal oxygen saturation and retinal diseases.

Currently, retinal imaging equipment is not only costly to purchase but require skilled personnel to operate. As a result, there is a disparity in the diagnosis and treatment of retinal disease amongst developing and developed countries with 1-2% of the population in developing countries suffering from blindness compared to less than 0.5% in developed countries (Sommer et al. 2014).

Increasing advances in the processing capabilities, connectivity, camera and sensor technology of smartphones and their abundance has propelled smartphones into the spotlight as a cost-effective alternative to expensive medical diagnostic equipment. As a result, a new era of ophthalmic technology was born, Smartphone Opthamology, bringing with it the prospect of delivering eyecare in settings that were once not previously possible.

This project concentrates on a specific modality of retinal imagining called retinal oximetry. Retinal oximetry was chosen as a focal point due to the significant role blood and blood vessels play within the body and their correlation to certain diseases such as Glaucoma, Diabetic Retinopathy and Retinal Vessel Occlusions. The development of such technology would aid in mitigating the prevalence of retinal diseases in not only developing countries but amongst groups that cannot access the technology such as those who are immobile.

This project encompasses the design and development of an light emitting diode illumination system for a retinal imaging module that will attach to a smartphone creating a portable, cost-effective and functional device to aid in the detection and subsequent diagnosis of various ocular and systemic diseases.

Optimizing the Generation of Physiologically Relevant Multicellular Tumour Spheroid Models - (12cp)
Nicholas Rabey - S18-110

Supervisor: Associate Professor Majid Ebrahimi Warkiani
Major: 120cp Biomedical Engineering major BE, BE DipEngPrac

Cancer is a group of diseases characterized by abnormal cell proliferation and is one of the leading causes of death worldwide (World Health Organization 2019). Potential new treatments must undergo a rigorous trialing process and experience low success rates (Thomas et al 2016). One explanation for this is the lack of suitable in vitro models that accurately recapitulate the in vivo tumour microenvironment, leading to adverse or unforeseen effects in animal and clinical trials. Multicellular Tumour spheroids (MCTS) display more similar properties to primary tumours than traditional two-dimensional cell cultures (Ham et al. 2016) and represent an effective method to recreate the complex cell-cell and cell-matrix interactions of the tumour microenvironment.

Co-culturing cancerous and non-cancerous cells in a three-dimensional environment is a vital step in recapitulating the heterogeneous nature of tumours in vitro and improving our understanding of the mechanisms which enable resistance to current treatments, however the complexity of generating such cultures continues to hinder progress. Technically, Microwell arrays have emerged as a relatively simple method to generate spheroids and demonstrate many advantages over traditional techniques including high throughput, low labor-intensiveness and extended culture periods (inCyto, Korea), however there is limited available information on how this approach can be applied to more complex spheroid cultures. The aim of this project was to optimize a protocol for the generation of multicellular tumour spheroids consisting of multiple cell types that more accurately mimic tumours in vivo by means of microwell array approach.

MCTS’s were cultured from MDA-MB-231 triple negative breast cancer cells using a microwell array (inCyto, Germany). Heterogeneous spheroids were generated by co-culturing MDA-MB-231, Human Lung Fibroblasts (HLFs) and Human Umbilical Vein Endothelial Cells (HUVECs) at ratios of 1:1:1, 1:2:1 and 1:5:1 prior to seeding in microwells. Morphology, average diameter, count and cellular distribution of spheroids were assessed using confocal microscopy.
The Rugged PCR: Design Optimisation of PCR Machine for Use in Rural Communities as a Diagnostic Tool for Contaminated Water Testing - (12cp)
Prashanti Sarala - S18-264

Supervisor: Dr Nham Tran
Major: Bachelor of Engineering (Biomedical) Bachelor of Business

The pollution of water supplies in remote areas of developing countries is a problem that is affecting a large populations’ health, and action is required to improve these conditions. Efforts to improve water conditions and supply in remote areas have been extensively studied and there are many existing responses to the problem, such as the implementation of new pipelines and chlorination of the water at the source. However, many of these initiatives have failed to succeed as they have not been properly facilitated by an approach that is supported by the education of health and the importance of understanding why the bacteria in the water should be tested and the significance of the test results. Without this understanding any new initiatives have been hindered by the lack of participation by the inhabitants of these rural communities to continuously improve and maintain the improvement of their water supply. To combat this issue, it is evident that the ability to test water in these areas is a process that needs improvement and greater accessibility to equipment is required.

This project incorporates the development and design optimisation of a portable and rugged Polymerase Chain Reaction (PCR) device for use as a diagnostic tool. The objective of the project is to create a durable design that is cost effective, replicable and user friendly so that local members of community can be trained to use the device independently. The goal of this design is that it promotes the need to continuously test water supply in rural communities and ultimately reduces the number of deaths and illnesses caused by water pollution.
Drop Ship vs in Clinic Set Up for the Healthcare Industry - Sleep Apnea - (12cp)
Annick De Silva - S18-117

Supervisor:  Associate Professor Valerie Gay
Major:  114cp Biomedical Engineering Major BE BBus

The health industry is going through a change with increased pressure on cost and managing patients efficiently. It is being further impacted with technology advances and consumer and patient needs combining. The compound of cost and advancement sees the need to understand how to effectively meet stakeholder needs in this new landscape. A need that has become apparent is for devices (medical and non-medical) to become easily accessible, delivered as needed and user friendly for set up and management of health. This is a change from the original in clinic set up and clinician management model that stakeholders are accustomed to.

The sleep apnea industry is one that has grown over the last 30 years and is required to understand this change. Key manufacturer Philips Respironics is leading this evolution with a commercially launched Patient Management System which allows a patient to receive their device via mail order and then are educated and set up through their services.

In this project sleep apnea company ResMed is looking to understand the workflow of how to send a sleep apnea device to a patient, set them up and effectively keep them compliant on therapy in comparison to in clinic set up. This will be aimed to meet the needs of the patient, medical provider, clinician, general practitioner and insurers. Data acquired internally will be used to create a commercial plan to help aid stakeholders in their journey to cost effectively send devices to patients in a preferred method for the patient whilst educating them on the journey. Data driven requirements have also been driven to technology and design teams within their Research and Development space to improve products or services for the future.
A Critical Success Factor (CSF) Based Model for Small Value Projects for a Hydraulic Sub-Contractor in Australia - (12cp)
Niccolo Velez - S18-097

Supervisor: Dr Alan Sixsmith
Major: Civil Engineering Major BE and BEDipEngPrac

Project success is important as the success and/or the failure of a project affects everyone – stakeholders, contractors and the community. Understanding how a project can be successful assists in mitigating failures prior to, during and at completion of a project.

Preliminary research of scholarly articles was undertaken to understand what project success is, existing solutions, and a review of this research’s potential impacts, uncertainties and risks. The engineering challenge is to come up with a tool that allows hydraulic subcontractors to constantly view their project with a certain mindset prior to, during and at completion of their projects. The research project’s objective is to come up with a framework consisting of success factors deemed to be critical, that has been tailored for a hydraulic subcontractor to use. Doing so will provide the hydraulic subcontractors a tool and/or guide to assist in running projects more smoothly, knowing that they have acknowledged the main success factors (as per the framework) and have therefore made necessary steps to minimise failures in their projects.

A questionnaire was conducted, alongside interviews of people with sufficient job knowledge (for e.g. a hydraulic project manager). This attempts to gain cohesiveness and a link between the preliminary research involving the scholarly articles and today’s hydraulic subcontractor. Based on preliminary results, the critical success factors deemed to be the most critical were: Time, Budget, Specification & Communication. Finally, a critical review of past and current projects took place to validate that the model relates to the success of a project.
A Critical Success Factor Based Model for Major Work Projects for a Hydraulic Subcontractor in Australia - (12cp)
Sarah Kirkup - S18-228

Supervisor: Dr Alan Sixsmith
Major: 102cp Civil Engineering major BEBADipEngPrac

The construction industry and scholars have long been investigating the most effective means of achieving project success. With the growing population, the demand of infrastructure and services has increased the size and scope of the projects in Australia. Hence, understanding and achieving project success has become vital in fulfilling project goals and having a positive impact on the social, environmental and economic contexts.

Preliminary research into literary articles provided a thorough insight into the range of success factors within the construction industry, what project success is, existing models and the influence of the complexity of a project on the success of a project. Studies on project success regarding hydraulic subcontractors in Australia is lacking, which had provided the engineering challenge of creating a relevant model that shows a snapshot of the most critical success factors. This can then be utilised by the hydraulic subcontractor as a guide to achieve more successful outcomes.

The aim of this thesis is to make this model applicable to a hydraulic subcontractor undertaking major projects in Australia. This was done through conducting a questionnaire with people in the hydraulic and construction industry to validate the current research regarding critical success factors. This has been validated further through interviewing project managers with sufficient ‘major work’ project knowledge.

Preliminary research through these methods has identified time, budget, specification and communication to be the top 4 factors. Comparisons will be made with the research undertaken by my colleague regarding small projects to provide an insight into factors that are size related to make further recommendations.
Understanding the Effects of STEM Programs on the Diversity of Engineering Students - (12cp)
Shayal Singh - S18-041

Supervisor: Associate Professor Anne Gardner
Major: Civil Engineering Major BBEBBus and BEBsc

Low levels of gender diversity has been a prevalent issue in the engineering sector and are exponentially gaining attention in the engineering and education sector and leading to an increased number of gender diversity programs running. There has also been an increased focus on low levels of gender diversity in Science, Technology, Engineering and Mathematics (STEM) as a whole. While this is much-needed awareness, a thorough literature review found that other minority groups (beyond gender) in the engineering and STEM sector aren’t being actively targeted in these programs.

This study primarily explores the following issue: the influence of STEM Outreach programs on those who attend, the impact of being able to identify with someone in Engineering on one’s career decisions and the need to increase awareness of the career opportunities engineering has to offer. The study collected both quantitative and qualitative data from students in the Faculty of Engineering and IT at the University of Technology Sydney.

The results of this study are detailed throughout the latter stages of this report and in the appendix, with a critical analysis of the data presented the discussion. This study presents the advantages and limitations of current STEM Outreach programs. Discussion of the findings leads to a series of appropriate recommendations being presented on how to increase the awareness of engineering opportunities to future generations and to ensure maximum inclusivity is seen in the engineering sector.
Development of an Innovative Program to Calculate the Load Capacity of Helical Piles - (12cp)
Yipu Guo - A18-245

Supervisor: Associate Professor Hadi Khabbaz
Major: Civil Engineering Major BE and BEDipEngPrac

Helical piles, also known as screw piles, provide an efficient and versatile alternative to conventional anchors or deep foundation in a broad variety of applications. Their awareness, acceptance and usage by engineer community are significantly increasing in recent years because of their unique advantages against conventional piles such as rapid installation and no casing/dewatering required. Nevertheless, helical piles are new type piles and there are no relevant engineer literatures prior to 1950s. Due to the existing of the three - dimensional helices, the complexity of configuration and multiple influencing factors of pile-soil interaction, the bearing mechanism of helical piles is far more complex than conventional piles.

For this reason, the study on different failure modes and various approaches predicting axial capacity of helical piles has been made in this thesis, in order to satisfactorily develop a program using MATLAB software to calculate the ultimate bearing capacities of the helical pile under vertical load. A visualized Interface which enables user to friendly interact with computer is developed using MATLAB software, as the final project demonstration.

A dynamic figure is animated via interactive interface to synchronously simulate the graphical configuration of helical pile, as well as the profiles of soil strata and water table, with reference to the parameters inputted by the user. This program is capable of carrying out a parametric analysis to evaluate the relationship between ultimate axial bearing capacity and helix diameter – shaft diameter ratio. The validity of theoretical outputs is evaluated by LCPC method which directly correlates experimental results of cone penetration test (CPT) with ultimate bearing capacity by applying reduction/scaling factor to CPT profile of the tip resistance, with no intermediate determination of soil strength parameters.

This program enables geotechnical engineering industry to calculate the ultimate axial bearing capacity of the special-shaped piles, helical piles with a reasonable degree of confidence. Further exploration is required.
Improving Earthquake Resistance of a Multi-Story Building Under Seismic Loading - (12cp)
John Sarmiento - S18-116

Supervisor: Professor Jianchun Li
Major: Civil Engineering Major BE and BEDipEngPrac

While it is publicly known that earthquakes are known to produce some of the largest numbers of fatalities in the world, the real cause of these disasters is the failures of the buildings and structures (Rahman, 2018). Modern engineering has been able to produce several technical solutions to improving a structure’s behaviour against seismic loading, such as base isolation and mass dampers. However, there is great value in finding innovation in the area of improving the earthquake resistance in the structural design of a building and, in the process, encouraging greater understanding in the field of earthquake engineering from university students.

This project explores different techniques and designs that aim to increase the earthquake resistance of a multi-story building. An understanding of structural dynamics and earthquake engineering is developed through a three-stage learning model with the aim of improving a student’s understanding of earthquake engineering through practical means with each stage involving their own building model to be tested experimentally.

This project is held within the context of an undergraduate earthquake engineering competition, based on existing university competitions, with the aim of drawing out innovation and creativity from students. This will involve a scenario where students must design an earthquake resistant building under design constraints from architectural specifications.

This project also explores the utilisation of the new MAST Facility located in the UTS Tech Lab in order to simulate earthquake loading onto the building models. Acceleration and displacement values, as well as the maximum earthquake intensity experienced, is used to compare and assess the behaviours of all models.

The project aims to assess the effectiveness of the earthquake-resistant designs and provide recommendations on implementing the learning model into an earthquake engineering competition using the shake table.
Application of Fracture Mechanics for Evaluation of the Self-Healing Effectiveness of Encapsulated-Based Smart Concrete - (12cp)
Letizia Villa - S18-071

Supervisor: Professor Jianchun Li
Major: Civil Engineering Major BE and BEDipEngPrac

Concrete is a very versatile and strong construction material, however it is also prone to cracking. Concrete may crack due to a number of reasons, including moisture content, temperature change, structure settlement and service or excessive loading. While initial cracking is unavoidable and acceptable, the propagation of cracks could compromise the safety, reliability and serviceability of a concrete structure. While constant maintenance represents the traditional preservation method, smart concrete technology is attempting to provide an innovative solution by introducing a smart functionality within the concrete material itself.

Encapsulated-based self-healing concrete is one of the many types of smart concrete being developed in this time of industrial innovation. This technology aims to overcome the issue of problematic cracking by stopping their propagation and regaining engineering properties. This is achieved by filling the cracks with a healing agent that glues the crack surfaces together to prevent further crack growth. Upon concrete fracture, the ceramic capsules that lie within the concrete matrix also break and release the gluing agent to achieve the self-healing function, somehow imitating the human body.

The project begins by looking into a state of art overview of the smart concrete technology and the different products that are being developed. The project then focuses especially on the encapsulated-based smart concrete. It applies the theory of engineering fracture mechanics to evaluate the healing effect of this modern concrete technology by modelling the stress response and recovery of a healed crack. Furthermore, there is also the aim to investigate the influence parameter which optimizes the effect of self-healing so to provide a guide on the procedure to obtain the most efficient engineering properties regain. The result of this project will enable future researchers to model and design the most effective glue, which is currently designed by mere experimental trial and error.
Vehicle Impact Performance of Normal Strength Concrete and Ultra High Performance Concrete - (12cp)
Jing Ao Zhang - S18-136

Supervisor: Dr Jun Li
Major: Civil Engineering Major BE and BEdipEngPrac

Vehicle collisions account for roughly 15% of total bridge failures in the USA. Current design standards do not adequately account for the complex nature of impact loading which involves high non-linearity in both the material and structural behavior. The widely adopted bridge design standard, AASHTO-LRFD, recommends that columns likely to encounter vehicle collisions must be able capable of withstanding a static load of 2670 kN applied at 1.5m from the base of the column. This is not adequate to withstand a full loaded heavy vehicle in a high-speed collision.

This project aims to study the impact resistance of concrete column with various geometrical configuration and material composition. This study is primarily based on numerical study through the LS-Dyna finite element analysis software. Conventional strength concrete columns with varying compressive strengths and stirrup reinforcement spacing are investigated. The results are compared with columns built with the emerging constructional material, i.e. ultra high-performance concrete (UHPC). A detailed Toyota RAV4 model is utilised as the collision vehicle and impact occurs at different velocities. Front on collisions and 45-degree angled collisions are also studied.

Numerical results based on the validated structural and material model reveals that the conventional concrete specimens experienced brittle shear failure almost instantaneously upon impact contact, especially in the lower grades of concrete. Ultra-high performance concrete column underwent greatly reduced local damage and deflection. It is without a doubt that the UHPC columns performed the best across the board demonstrating low deflection, high shear resistance and the ability to withstand the impact load for a longer duration before failure. However, further study is deemed necessary to further improve its cost-effectiveness to ensure its application in the near future.
Analysis of Passenger Behaviour at Town Hall And The Solution to Chronic Congestion that Disrupts Train Services - (12cp)
Jasper Ryan - SU18-065

Supervisor: Dr Michelle Zeibots
Major: Civil Engineering Major BE and BEDipEngPrac

In the year 1800, 7.3% of the global population were living in urban areas, in 1900, 16.4%. 119 years later, more than half the world’s population is now living in urban areas and is predicted by the UN to increase to 70% by 2050. This drastic shift has been accompanied by a wave of the socio-economic opportunities that stem from the proximity that cities offer, and these benefits are pivotal in sustaining a flourishing society. The ability to quickly travel through a city to make exchanges is crucial, but the increased demand on transport services when not appropriately designed for can lead to crippling delays, damaging the original benefits that a city provides.

Sydney Trains is facing the challenge of a city with a booming population and insufficient resources to reliably meet that rising demand. Town Hall Station has the highest demand in the CBD during peak times, and its central location means local delays can affect the whole urban network. The major source of delays this capstone identifies is passenger congestion on the platforms. The platforms were built in 1932 for a smaller population and expansion is now impossible. The platforms have a capacity that is increasingly being exceeded, caused by congestion at critical ‘choke points’ on the platforms. Too many passengers on the platform prevent the train’s passengers from alighting, meanwhile more passengers enter the platform via the stairs and exasperate the congestion, delaying that train and all trains on that line behind it.

This capstone investigates the passenger flow and behaviour that leads to the formation of ‘Choke Point Alpha’ near the north entrance to Town Hall Platforms 1 & 2. This project also explores ‘nudges’ to the system that may reduce congestion, particularly around the decision making that passengers make on their journey through the station.
Investigation of Fire Rating Requirements for External Wall Cladding in Residential and Commercial Buildings - (12cp)
Joshua Duggan - SU18-034

Supervisor: Dr Nadarajah Gowripalan
Major: Civil Engineering Major BE and BEDipEngPrac

As the increasing demand for high-rise buildings unfolds, construction speeds are accelerating past the design of building regulatory ecology. The fundamental problem is that building regulation is slow to evolve, and the governing bodies are not proactive in their review of a changing industry. In fact, regulation is only ever reactive, implementing strict change whenever a crisis occurs.

This has been most recently demonstrated in the wake of multistorey building fires that occurred due to exterior wall assemblies containing combustible composites, such as the Lacrosse Apartments in Melbourne (2014) and Grenfell Tower in London (2016). In response, the Australian Government has prohibited the use of Aluminum Composite Panels (ACPs) that contain a core with greater than 30% polyethylene by mass, and when used as part of an external wall assembly in buildings of Type A or B construction.

The challenge confronting the nation is that there is no legislative mechanism designed for the adoption of uniform standards across the state governments operating within Australia. As well, due to the continued instability of the profession, this report with highlight the desperate need to implement a viable solution on the retrospective ban of non-compliant ACPs, currently installed on existing and occupied buildings.

In conjunction with an analysis on the history, legislation and stakeholder interaction on the combustibility problem, an investigation has been undertaken to present extensive and valid findings on both the existing and innovative products that have been introduced in accordance with the different pathways to compliance under the recent reforms to the National Construction Code (NCC) and introduction of a new full-scale wall test.

The scope of this report will capture consumer and industry feedback coupled with early warning detection research. This will allow diagnostic research to be transmitted globally when a major fire incident occurs, forcing lessons learnt to be incorporated into local thinking and actioned into law reforms and recommendations of new compliant products for use in future building construction.
The 21st Century has seen a rapid increase in industrialization and technological advancement. Consequently, it has led to the production and disposal of considerable amounts of resources i.e. plastics, glass and paper. (Sörme. L et.al. 2019). However, the problem doesn’t lie with producing these materials, but rather with their safe disposal. Management of these municipal waste in the community is a problem that threatens the wellbeing of the flora and fauna in the environment. Apart from Cement and Steel, the use of plastic is the most prevalent in our society. (Geyer R. et.al. 2017), and thus, Engineers around the world are faced with an uphill battle to find a solution to this recyclability issue, with one potential outlet being to use it in road construction.

It is estimated that in 2015-16, only 293,900 out of 3,513,100 tonnes of plastic consumed in Australia were recycled; leaving an astonishing 91.6% as waste/potential waste. (Department of Environment and Energy, 2017). Currently, the two main modes of plastic disposal are “landfills” and “dumping in the ocean”, both of which are harmful to the environment and promote global warming if not properly handled (Ashford. M, 2010).

The aim of this project is to investigate the potential and extent to which these plastic wastes could be treated, recycled and incorporated into the construction of road pavements i.e. as road fill and part of the asphalt mix. This has taken into account the practicality of this practice, optimum aggregate size of the recycled plastics and the preparation methods. Keen focus is paid on the environmental impacts, marketability and durability of the subsequent recycled roads. PLAXIS was used to model two different types of ground layers/conditions which mimicked the behaviour of a ‘recycled road’ and a ‘road built with virgin quarry aggregates’. Along with results discussion and detailed theoretical research, interviews with industry professionals were also carried out with the aim of understanding current market trends.

References:
- Environment NSW 2017, 2016-17 Australian Plastics Recycling Survey, viewed 10 May 2019, [Link]
Assessment of Road Tunnel Stability using Finite Element Modelling: Specific Reference to the WestConnex Tunnel - (12cp)

Mariah Owen - S18-092

Supervisor: Dr Sanjay Nimbalkar
Major: Civil Engineering Major BE and BEDipEngPrac

As the population increases, a larger amount of goods are required to be transported around the country. Heavy vehicles carrying freight have a need to utilise the fastest and most convenient transport networks available, often involving road tunnels. Tunnels provide “three-dimensional freedom” (National Research Council 2013, p.1) and have fewer spatial limitations than most densely populated areas situated above ground. The M5 WestConnex tunnel in Sydney, part of a new major multi-lane roadway, will open in 2020 and is designed for heavy and commercial vehicles to use every day.

In this study, stresses and deformations in tunnel road pavement and soil mass surrounding the tunnel will be investigated using the finite element approach, specifically using 2-D PLAXIS. A typical urban traffic load distribution data set will be considered where different classes of vehicles will be used to determine the resulting effects the traffic has on the structure. The selected soil profile, tunnel design and pavement material is similar to that of the WestConnex tunnel and existing site location. Additional methods widely used in the industry AS 3725 (Standards Australia 2007, p. 23), Westergaard, Burmister and Boussinesq are compared against the PLAXIS results.

Of the methods tested, it is considered that PLAXIS is the most accurate for predicting the pavement and soil behaviours of vertical stress and deflections causing by vehicle loading. It has been noted that using finite element models such as PLAXIS will not deliver an outcome which precisely reflects actual site behaviours unless proper calibration and validation of parameters is performed.

References:


Finite Element Modelling of Railway Track Using Geocells - (12cp)
Nattapong Sumonta - S18-158

Supervisor: Dr Sanjay Nimbalkar
Major: Civil Engineering Major BE and BEDipEngPrac

The objective of the capstone report is to implement commercial finite element modelling software package PLAXIS 2D to simulates geocell-reinforced track structure in two dimensions. The computer modelling was conducted to simulate the track structure located on two different types of subgrade conditions, namely bedrock and soft soil. The axle loads are 25, 30 and 35 tonnes.

The validation of the modelling was conducted considering the results from the published articles and theses. There was an agreement between the results from computer modelling and the results found from the literature. Geocell can be simulated by using geogrid function in PLAXIS 2D with some limitations.

The parametric studies were also conducted using PLAXIS 2D to observe the relationship between the location of the geocell and the parameters, namely horizontal and vertical deformation under the axle load, the vertical and horizontal Cartesian vertical stress under the axle load, horizontal deformation along the side of the embankment, and Cartesian vertical stress on the subgrade layer. Furthermore, horizontal deformation along the side of the embankment and vertical Cartesian stress on the subgrade layer were analysed by using two different values of soil friction angle and elastic modulus.

The results from the parametric study show that the location of the geocell influences the horizontal and vertical deformation under the axle load, and Cartesian stress of the track structure located on the soft soil subgrade. The varied geocell location has its own advantage and disadvantages. Predominantly, geocell performance is good when it is embedded 300 mm below the bottom of the concrete sleeper, whereas geocell does not make any contribution when it is located 400 mm below the sleeper. The location of the geocell does not remarkably influence vertical and horizontal Cartesian stresses, and deformation of the track structure located on the bedrock subgrade.
Organic Waste Recovery Practices and their Potential for Utilisation in Australia- (12cp)  
William Ireland - S18-123

Supervisor: Professor Wenshan Guo  
Major: Civil Engineering Major BE and BEDipEngPrac

This project’s aim is to review the organic waste problem in Australia and put forward solutions to utilise this form of biomass as a source of energy or to be made into products. Australia recovers 52 percent of its organic waste, with the remaining being disposed of in landfill. Organics left to decompose in landfill produces methane, 20 times more potent than carbon dioxide. Moreover, the option of landfill will become significantly more economically unsustainable in future years with limiting capacities and rising landfill taxes.

The technological solutions for organic waste recovery that were investigated are composting, incineration and gasification. Additionally, organic source-separation initiatives such as the co-collection of food and garden waste were examined. These methods were studied through literary analysis and comparisons, detailed international case studies applied to an Australian context, and through a conducted localised survey.

Findings show that a successful organic waste program can be linked with thorough source separation programs, government interventions and comprehensive waste-to-energy infrastructure. In Australia, composting remains the most common form of recovery with high familiarity and support from the public, with 66 percent of survey respondents showing support the co-collection of food and garden organics via composting to increase organic diversion rates from landfill. Recent incineration proposals across Australia have faced different outcomes on the basis of emissions and public concerns. When put against landfilling, public support for incineration is divided due to concerns regarding uncertainty with only 49 percent support. Gasification has shown to be an effective method of converting woody biomass with less emissions and higher efficiencies than conventional combustion, however it remains an expensive alternative for waste treatment showing limited examples of success stories overseas.
Fire Resistance Prediction of Concrete Using Soft Computing Methods (12CP)
Ante Wang – SU18-038

Supervisor: Yang Yu
Major: Civil Engineering

In the modern world, most of our civil structures contain concrete, as it gives the reasons why engineers and scientists are studying the properties of concrete. Thus, this could improve the ability of concrete by making a stronger and better quality. The most important reason why companies use concrete is that it is economical and recyclable. However, another main consideration is that it provides a better fires resistance than other construction materials such as metals as it could handle high temperatures, around maximum 1000ºC before it loses its strength.

Even to these days, fire is still one of the most dangerous hazards for human history as it delivers the most devastation for living organisms and non-living structures. For centuries, human is still researching the methods of minimising the fire hazards as it could reduce the casualties. As a result, many civil structures are using concrete as it has better fire resistance.

Concrete has been one of the most important materials for construction, so it is crucial to identify the reduction of compressive strength by using artificial intelligence (AI) techniques. In order to discover its strength, we need to identify how concretes are made.

Artificial Neural Network (ANN) is one of the latest developing technologies. Basically, it is an artificial intelligence technology as its ability could detect the strength of concrete by using its machine learning algorithms. There are numerous reasons of using ANN, and one of them is to reduce the human effort. This means, scientists do not have to bring concrete to labs to discover its strength after it contacts with fire. Thus, this could save us time and perhaps help us to invent other advance technologies.

When ANN has been fully developed, its advantage: it could predict an unknown data, after it learns its inputs and behaviour. This contributes to another benefit as this technology could tackle difficult challenges by overcoming inputs and outputs of complex nonlinear relationships.
Visualising Virtual Environments for Social Interaction - (6cp)
William Stewart - A19-324

Supervisor: Dr Tim Chen
Major: ICT Engineering major BE, BE DipProfEngPrac

Virtual Reality (VR) is a developing technology with a range of potential applications. There is a level of immersion for users of VR that is unmatched by any other simulation technology. As such, there are VR systems have and will be used in therapeutic and educational settings, in ways that have been heretofore not possible. However, there are a number of limitations to VR that can inhibit its effectiveness in such settings. One such limitation is a lack of meaningful social interactions between parties inside and outside of VR. That is, in a hypothetical therapeutic setting, the extent to which a therapist outside of VR is able to communicate and interpret how a patient inside a VR simulation is reacting is severely limited.

There are a number of approaches to mitigate these limitations and craft more meaningful social interactions between the two parties. This project will attempt to apply a number of these approaches, and apply them in a prototypical VR system. Namely, the system will visualize the VR user’s virtual world in a physical space using location tracking projections, such that the party in the physical world will be able to better understand how the VR user is interfacing with the virtual world. Another key aspect of the system will be the incorporation of biometric data from the VR user, visualized within the system such that the external party will better be able to understand how the user is reacting to the world. These improvements will provide an integrated and streamlined two-party experience with better opportunities for interaction.
Influence of Non-HMD at the Time of Reducing Stress on HMD Users - (6cp)
Jorge Villanueva Salamero - A19-325

Supervisor: Dr Tim Chen
Major: Software Engineering

Nowadays stress is one of the major problems in our fast-paced society, affecting not only our brain, and mental health but also our body, which reacts with physiological changes (e.g. accelerated heart rate), in a lot of cases triggered by the feeling of fear.

By using common stress-coping techniques, in combination with state-of-the-art technologies, such as Virtual reality, where artificial created environments and simulations are displayed to the user in an immersive 3D head-mounted display, and monitoring the body reaction through the heart rate, skin conductance, and if time allows the electrical activity of the brain. We aim to find a source of stress-alleviating for height and animal fears, which hopefully as we expect the experiments are proved to be successful, the results could be extrapolated to real-life situations and therefore help people worldwide in their daily days.

These experiments are and will be conducted at the - UTS Motion Platform and Mixed Reality Lab.
Amateur Microscopy for Scientific Imaging - (12cp)
Chen Xin Han - S17-303

Supervisor: Professor Chin-Teng Lin
Major: Bachelor of Engineering: Electrical

We are surrounded by common household objects and creatures in the wild. When magnified, a Band-Aid looks like a bird’s nest and butterfly wings showcase complex patterns. The magnified world is largely unknown. Another complex field of microscopy is digitising the scenery seen through the microscope. If amateurs and scientists alike can capture the stunning details seen through the microscope, it could potentially get more people interested in the undiscovered world.

With the advancement of modern photography, it is possible to utilise readily available camera systems to capture the details. The most crucial problem is depth of field (DoF), which is the areas that are in focus. Objective lenses used in microscopy has a DoF in the micron-range. With such a thin band of focus, little detail can be seen with single exposures.

An acceptable system must feasibly solve the problem of DoF. There are several approaches to address this, one of which is focus stacking. Multiple photos are taken at fixed intervals smaller than the DoF of the objective, the acquired images taken at different step lengths are blended together, yielding one photo with exceptionally large DoF. Luckily, utilising motorised rails found in the automation industry makes this process simple. The objective is to build a versatile system that handles focus stacking.

After extensive research and preparation, the microscopy setup is finalised. An exposure of 3 seconds is achieved in a controlled environment. The system is highly dependent on the location and surroundings due to being vulnerable to vibrations. All objectives are met when external vibratory sources are accounted for.

Summing up, the amateur and hobbyist with the right tools can create photographs in the visible spectrum that rival or surpass ones taken with high end scientific microscopy systems in terms of resolution. The report also explores outside of the visible light spectrum, brainstorming potential possibilities in fluorescence.
Buck-Boost Power Supply with CAN bus Diagnostics and Control - (12cp)
Liam Caruana - S18-030

Supervisor: Dr Dylan Lu
Major: 114cp Electrical Engineering major BEBBus BEBSc

Microgrids are an electricity network supplied by local sources of electricity such as solar and wind. This network can be used in conjunction with the grid to provide supplemental power at a lower cost to the consumer or as an independent self-sustaining system. The benefits include access to a reliable source of power in remote locations, energy independence and the increased adoption of renewable energy.

The objective of this project was to design and develop a DC-DC convertor as part of a modular system that uses the Controller Area Network (CAN) protocol to negotiate load sharing. CAN has a sizable presence in the automotive, automation and medical industries when reliable, high speed data transfers are essential. CAN is also a robust protocol containing five methods of error checking in hardware that remove erroneous packets on the bus without any software intervention.

A prototype system was developed as two separate hardware projects; a power converter module and a base board with a microcontroller and CAN interface. Load sharing of parallel supplies was implemented by regulating the output voltage of a ‘master’ module and current control of subsequent modules on the DC bus. This was achieved using the broadcast voltages and currents on the CAN bus in the firmware control loop.

This project serves as a proof of concept for CAN communications in a low power DC microgrid system. This method could be inexpensively adapted for high power AC systems through modifying current technologies and ultimately replacing existing proprietary solutions. There is also the potential for a secondary use in automated device under test systems where programable power supplies can test for faults after printed circuit board assembly.
A Buck Converter (BC) is a power converter topology normally used to step-down and invert DC voltages. BC can be used as a DC or AC voltage source using the appropriate closed loop control to maintain the output at the desired state and compensate for voltage drop during varying load currents. Typical applications include DC motor control and photovoltaic energy harvesting.

The closed loop control for the BC would require the following parts: isolated voltage and current measurement, signal conditioning, digital conversion, software implementation of the control system logic and a quadrature pulse width modulation output to apply to the H-bridge of the BC. All these steps could be accomplished with some degree of success on a simple micro-controller. However, the aim of this research is to use a very high sample rate and control processing rate not possible with any micro-controller; this task is accomplished using a custom architecture programmed into a Field Programmable Gate Array (FPGA).

The research goal is to develop the hardware and software design to create all the components required to regulate output voltage from a buck converter with an acquisition rate of 4.5 million samples per second of voltage and current. This design can later be expanded to create a constant current or constant power supply. The hardware product must be industry standard and safe to operate up to ±100 volts. The software must be fully operational and flexible enough to allow future research development. Mechanical design must secure all part of the design neatly and provide appropriate protection for components.
Advanced Security Door Lock Using the Face Identification and Fingerprint Sensor - (12cp)  
Quoc Vinh Nguyen - S18-150

Supervisor: Dr Ha Pham  
Major: 120CP Electrical Engineering Major BE BEDipEngPrac

Biometric authentication solutions are fast becoming the antidote to clunky, inconvenient and easy-to-forget strong passwords. Mobile fingerprint scanning technology such as Apple Touch ID is already a global mass market with broad consumer acceptance. The pattern of ridges and valleys found in your fingerprint is unique to you – not even identical twins share the same fingerprint – and as such it is one of the most important pieces of biometric information that distinguishes you from everyone else.

Smart door with face recognition as well as fingerprint scanner are an easy way to increase the security of your home or rental property. You can allow access for a service technician without leaving instructions for a hidden key. Furthermore, you can change codes or passkeys to allow rental guests limited-time access. Family or friends can enter your home to feed the fish or check the pipes. And, no more fumbling for keys while standing in the rain or cold. Some smart locks can sense your approach and immediately grant you access.

The most compelling reason for installing a biometric lock is to improve security. You won’t have to worry about thieves “jimmying” the pins in a traditional keyed lock to gain silent entry to your home or property. Most smart door locks don’t use keys; and the options that do allow a traditional key for entry are not easily defeated like traditional locks.

Our project focuses on the importance of fingerprint uniqueness as well as the distinguish features of human faces by combining the knowledge from microcontroller and the software related to the fingerprint and face recognition technique to accomplish this. With the 2 elements combined together, the security aspect has been improved significantly to further improve our confidence in a safer world.
Advanced Security Door Lock Using the Face Identification and Fingerprint Sensor -
(12cp)
Quang Thai Ta - S18-150

Supervisor: Dr Ha Pham
Major: 120CP Electrical Engineering Major BE BEDipEngPrac

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The Separable Automatic Emergency Braking of Car- (12cp)
Vu Tran - S18-075

Supervisor: Dr Ha Pham
Major: 120CP Electrical Engineering Major BE BEDipEngPrac

It is not denied that car ownership has been increasing significantly, this issue accompanied by a steady rise in traffic digestion, followed a road accident. To ensure the driving safety level and avoid the road traffic crashes, an anti-collision strategy becomes more mature can be installed to the car by the automatic emergency braking system (AEBS).

AEBS can identify car of the object in a dangerous zone or distance adjusted and set up by a radar (sensor) or camera, which is installed in front of the car, run effectively in case the driver is not aware of the danger of in front of car or object. The AEBS work operates electronically to avoid crashes and reduce collision. In the recent decade, an enormous number of automatic emergency braking (AEB) car has been manufactured for the demand for consumption. However, it is not extremely cheap for a brand-new car utilising the AEB system which is modern technology. To own an AEBS car, the customer needs to a pretty high amount of money to able to buy a car just because of the AEB system, and this will not satisfy the customer’s demand.

This paper will propose a new automatic emergency braking which is flexible, separable, and low-cost. As the separable function, my AEBS design can be able to be installed quickly to the conventional cars which are old generation cars. This design will apply the Arduino-microcontroller run along with an ultrasonic sensor for completion progress. Using the digital, I will apply the algorithms for the braking objective which is the car is unable to move forward whenever the sensor recognises the obstacles in danger zone/distance, but the car can be able to reverse.
How does a deaf person know that a fire alarm is going off, or an elderly person who is hard of hearing realize that somebody has rung the doorbell. I saw a need to take standard alarms around the home, which are usually purely audible in nature, to transform them into other mediums; physical, audible, and physical.

Instead of developing the notification delivery system (a task which could be achieved with smart watches or phones), I decided to focus on sensing alarms using a common IOT (Internet of Things) microcontroller, the ESP32, to sense alarm events and communicate with a base station wirelessly. I broke my project up into a few main components, firstly I confirmed the theory behind sensing simple monotonic alarm frequencies using the scientific program MATLAB. From the confirmation of the theory I moved to software development of the ESP32 microcontroller, writing and finding various libraries in the c programming language to develop a portable, wireless, and universal alarm sensor system.

Being a prototype and proof of concept, the theory was confirmed in the early stages after my initial method of sensing alarm event was not going to work theoretically or practically, so I achieved a working model and proof of concept. As well, I successfully developed pieces of software to control a microcontroller in an architecture that I was unfamiliar with prior to commencing this project. Overall the project has also taught me valuable lessons in scope, time and resource management, and persistent problem solving when there is no obvious way forward or any ‘experts’ in a particular framework around. I believe this project can potentially be a viable product with further research and development in the future.
Potential Crack Detection within Images of Infrastructure - (12cp)
Michael Dmitrewicz Kostrzewa - S18-064

Supervisor:  Associate Professor Quang Ha
Major:  120cp Electrical Engineering Major BE BEDipEngPrac

Infrastructure requires ongoing maintenance to remain in safe operating conditions. Long term deterioration presents an ongoing threat to the health and safety of many stakeholders. An automated means of detecting damage in its early stages presents an opportunity to significantly reduce the cost of preventative maintenance and minimise risks long before they become a real danger.

The focus on the automated detection of potential damage within images, cracks explicitly, in a high natural noise environment. Taking into account texture and lighting conditions a simple pre-processing method utilising mathematical morphology is employed to prepare image regions for classification.

An experimental dataset consisting of images containing pavement cracks is selected as it representative of a typical first data set acquired. The data preparation methodology and appropriate feature descriptors are selected based on an analysis of the initial images. A Linear support vector machine is used to classify regions within an image as potential cracks, and a genetic algorithm is used to select an appropriate subset of training parameters to obtain a more robust fit on the experimental dataset.
Robust Robot Localization and Map Building Using 2D Laser Data - (12cp)
Qianyi Guo - SU18-064

Supervisor: Associate Professor Shoudong Huang
Major: Electrical Engineering major BE BEDipEngPrac

Robust robot localization and map building using 2D laser data
Nowadays robotics is one of the most popular technologies. The SLAM (Simultaneous localization and mapping) is an important topic in robotics. Using SLAM, robots can replace human to navigate in dangerous terrains. Or robot can enter the tiny environment (such as the blood vessels within a human body) and perform necessary operations. One important SLAM application is around the development of driverless car.

This project use ICP (Iterative Closest Points) to perform SLAM using 2D laser data. The ICP is a method that try to register two clouds of points by estimating the relative xy coordinates and rotation. Because the project data come from 2D laser, we use normal vector to improve the ICP matching result following the idea of point to line ICP. Because of the complex environment and the existence of bad points, the project using four different ways to filter bad points. The first way is to delete set of less than or equal to three points but far away from other points. The second way is delete calculation with a point, before and at the back of the normal vector points, compared to the normal vector angle, the contrast angle is less than 90 degrees. The last way is to calculate the shortest distance of two point clouds one by one, and delete certain points that are the farthest away. The covariance matrix of the ICP result is computed and used in the pose-graph optimization step. It is shown that using different large-scale 2D laser data, the algorithm can optimize the robot poses and build high quality maps by adjusting and filtering method and properly choosing the initial values.
EMG Signal Processing for Upper Limb Rehabilitation - (12cp)  
Weili Pan - SU18-050

Supervisor:  Associate Professor Steven Su  
Major:  120cp Electrical Engineering Major BE BEDipEngPrac

Electromyography (EMG) is a type of electric signal generated by contracting muscle, by analysing this tiny signal under skin, people understand how the muscle operate. Knowing the principle of the EMG signal, which develops various application in different fields including biomedical, mechanical and electrical. For example, a robotic arm controlled by human’s arm and rehabilitate equipment for rehabilitation training purposes. It is obvious that EMG signal is not a simple sinusoidal signal to be analysed, as most of the muscular tissues in a muscle generate signal, the EMG signal we observe directly from the oscilloscope behaves tangled and hard to develop any feature. Hence, a signal processing and classification step becomes necessary to ensure the analysis can make progress.

In this project, it mainly consists of two sessions, an EMG signal processing and classification by machine learning (support vector machine) evaluated by MATLAB and a real-time EMG signal-controlled servo motor operation developed by embedded device MyRIO and LabVIEW, both are using EMG signal collected by Bitalino sensor kit. As for the MATLAB session, different featuring methods will be introduced and developed to proceed signal classification, including RMS (Root Mean Square), MAV (Mean Absolute Value), WL (waveform length) and FFT. Before the feature extraction and classification, steps of filter, pre-processing are necessary. There is a classification test and accuracy analysis after the support vector machine classification is trained. For the LabVIEW session, the RMS feature extraction method is used to develop an EMG signal-controlled servo motor operation, showing that the feature actual works in real world component.

This study explores the principle of how the muscle operate, and with the emerging technique of machine learning classification, indicating that such study is applicable to the real world and benefits people, illuminating further studies and innovative application in the future.