Department of Electrical & Computer Engineering

Final Year Project Descriptions

2016

E01: Sensors for Pallet Detection to Enable Fork Lift Vehicles to Engage with Wrapped Pallets

Sponsor: Crown Equipment Ltd

Introduction

The pallets in a warehouse will often be wrapped in layers of plastic film for protection of the products. Oftentimes these layers are not regular and can be wrinkled or "bunched up". This inhibits the visual guidance of the lift truck to engage its forks into the pallet. A sensor system is needed to "see through" the plastic film and locate the opening behind the stretch wraps, and give guidance feedback to the truck driver.

Project Objectives

The project should have achievable deliverables, with technical breadth so that each student has a distinct role in the team. Also a technical stretch is desirable to allow a good student team to extend the boundaries if time allows.

1	Academic survey of similar systems, and solutions in this industry.
2	Overview of the industry needs, including markets and cost benefit analysis.
3	Develop proof of concept hardware and software a lab based experiment to help development
4	Comprehensive report

Key questions for the project to answer:

a	Is there anything "off the shelf" that is suitable?
b	What solutions are currently possible/feasible?
c	What is limitations of the proposed solution? This is a low priority

Key measurements would be:

i	Quality and depth of industry survey
ii	Engagement with sponsor, with compilation of industry requirements
iii	Performance of proof of concept
iv	Final report quality

Project Scope

1	Specification for stretch wrapped pallet to be specified by sponsor
2	Dimensional constrains to be specified by the sponsor, but not the primary goal.
3	Reliability specified by the sponsor

Fields of expertise:

Depending on the solutions chosen, there may be requirements for interest in computer vision, signal processing, radar techniques, multispectral imaging and laser ranging.

E02: Airborne Sampling/Sensing of Distal Volcanic Ash

Sponsor: Defence Technology Agency

Background:

The threat of distal volcanic ash (VA) cloud to aircraft has been well publicised in the last 5 years with Eyjafjallajökull over Europe in 2010 and Puyehue-Cordón Caulle over Australasia in 2011. Much work has been done by the civil and military aviation sectors to address flight safety under the threat of VA, however several issues remain without ideal solutions.

Currently distal VA cloud envelopes are predicted with a combination of data from volcanic observations, satellite data and various other meteorological systems. These data are compiled into a set of aviation alerts for air traffic as managed by the regional volcanic ash advisory centres (VAACs) around the world. Present guidance recommends limits for ash density that define if an aircraft can be operated.

One key issue is that there a few means to directly sample or measure distal VA at altitudes encountered by aircraft. Measurement and sampling of actual distal VA is desirable as it allows a direct verification of VA cloud prediction models and allows researchers to study the VA itself to assess its composition and its potential damage to aircraft engines. Most VAAC models/predictions have reasonable levels of confidence in prediction of the areal coverage of VA but poor confidence in the resolution of the z component.

Although several nations have invested in piston powered aircraft fitted with an extensive instrument suite to directly measure distal VA, these systems are expensive and currently unjustifiable in the New Zealand context.

A distal ash cloud measurement system appropriate for the New Zealand context is desired by the NZDF and is supported by the NZ Civil Aviation Authority. The proposed project is to develop a low-cost method of sampling distal VA.

There are several aspects to this project, which may in fact form the basis for separate projects.

Project Objectives

The overall project objective is to develop a low-cost system to detect/measure/sample distal VA at altitudes used by aircraft.

There are several objectives DTA would like to see addressed in a 4th year project as below.

1. Development of a platform system that is capable of intercepting a distal VA cloud.
   a. System must be able to sample of reaching altitudes used by aircraft up to 40,000 ft.
   b. Ideally the system would incorporate some form of altitude control to dwell inside the VA.
   c. System must be low cost. For example a weather balloon attached to a decent glider could be an option.
   d. System should be able to sample VA and conduct a controlled decent for sample/sensor suite retrieval.
   e. Platform must have sufficient payload for sensor suite.

2. Development of a sensor package/telemetry to sense VA:
   a. Sensors must be low cost.
   b. Sensors at a minimum need to be able to robustly determine the presence of VA. This is important to determine the boundaries of the VA layer, which tends to stratify to relatively discrete layers.
   c. Ideally sensors would be able to measure the VA density to a level of accuracy that could be used to supplement/verify VAAC predictions.
   d. System ideally would allow data to be transmitted back to a ground station real-time.

Tentative project scope/schedule:

1. Research current state-of-the-art in distal VA cloud sensing.

   a. Review worldwide efforts to directly measure distal VA. Note that a number of universities and organisations have experimented with weather balloon and UAV based systems.
   b. Based on initial research define candidate concepts for a platform and also for the sensing/sampling system.

2. Development of a platform system that is capable of intercepting a distal VA cloud.
   a. Conduct basic flight performance modelling for candidate solutions. This should define predicted flight profiles to intercept VA at altitude and ability to retrieve system. Modelling will also require the use of meteorological data for wind direction, speed etc. Outputs of modelling will define the predicted flight performance and limitations of the proposed systems (e.g. payload, altitude, ability to retrieve etc.).
   b. Review and select candidate concept based on performance predictions. In addition consideration of the required airspace approvals required for launch should be made.
   c. Note that there is a strong dependence on the required payload for sensor suite.

3. Design and build prototype platform system.
   a. Rerun performance predictions for the as built prototype.
   b. For testing of the platform a dummy sensor payload may be used if sensor suite is not available.
   c. Review cost of as built design.

4. Flight test prototype design.
   a. Some form of telemetry or data logging system will be required to track platform.
   b. Conduct a series of flight to collect sufficient flight data.
   c. Develop performance map for the platform from flight data. Review this against initial requirements for sampling and conclude on performance of prototype platform.

5. Development of Sensor Suite/sampling system.
   a. The priority for sensor/sampling system development should be as follows:
      i. Sensor that can robustly detect ash i.e. qualitative output – 'ash' or 'No ash'.
      ii. Sensor that can measure the density loading of VA in the air.
      iii. System to take a sample of ash for laboratory measurement.

   b. Sensors selected should be off the shelf and low cost.
   c. A series of laboratory based experiments will be required to validate the accuracy/robustness of the selected sensors and sampling system. E.g. this might require development a test chamber into which a known quantity of fine VA can be suspended.
   d. Develop a data acquisition/control system to operate sensors and sampling system. This should also incorporate telemetry to transmit data to a ground station.

6. Field/flight test sensor system
   a. Devise outdoor ground based experiments to simulate VA encounters in real conditions and test. i.e. with use of actual VA.
   b. Flight test system to verify total system performance. The opportunity to test with an real distal VA cloud due to an eruption is unlikely. However background measurements of typical normal ambient conditions would be a useful baseline.

7. Develop low cost production worthy system. – Likely follow on activity depending on success of above.

8. Flight test developed system with a real eruptive event - future work.

E03: Power Quality

Sponsor: Electricity Ashburton

DESCRIPTION:

1. Ferro-resonance
The aim was to develop guidelines on when field staff need for take special precautions due the possibility of ferro-resonance. Two formulas for critical cable length have been analytically derived. One by Alex Baitch and the other myself. They differ by a factor of 2.
The project aim is to use PSCAD/EMTDC studies to reproduce ferro-resonance and determine which is correct. Then use this critical cable length to
form the guidelines. If time permits then mitigation methods can be evaluated. Maria Fernando worked on this two years ago but did not get a definitive answer.

2. Resonance Issue due to undergrounding/filtering.

3. False tripping's due to cable capacitance
Cable capacitance changes the flow of currents throughout the electrical network when a fault occurs. Rather than the protection system only isolating the faulty feeder, there is the possibility that the capacitance will increase the current that flows in a healthy feeder to the point it trips its protection due to a fault on a neighbouring feeder. There is a need to investigation at what level of capacitances this occurs, how significant is this problem, and determine possible mitigation techniques.

4. Laboratory testing of Mirus Lineator harmonic filter
Mark Empson (Director of Advanced Motor Control Ltd) has offered to let us check the performance of the Mirus Lineator harmonic filter he sells. We are ideally suited to do this with the new equipment we have available (namely the Ametek MX45 ac source). Knowledge of the performance of this product will add to the body of knowledge of mitigation methods, and enable a more informed selection of the most appropriate. If time permits, this can be expanded by comparing with standard passive harmonic filters. Besides the effectiveness as a harmonic filters, issues such as formation of resonances at other frequencies can be looked at. There is plenty of scope to extend this work.

E04: Inertial Sensor Based Orthopaedic Rehabilitation System

Sponsor: Enztec Ltd

Introduction: Enztec is an internationally recognised, Christchurch based, orthopaedic company that specialises in the design and manufacture of orthopaedic instruments. The company has a range of different products and services that are sold internationally to a wide range of different orthopaedic companies. Through its market knowledge and investigations Enztec has watched pre and post-operative tools and products become increasingly important and valued by distributors and surgeons. One such area that Enztec is interested in investigating is the development of tool to enable better monitoring and education of patient's pre and post-operative exercise regimes. For example patients having ACL reconstruction surgery have been shown to remove better if they exercise/pre-condition beforehand and can achieve key joint acceleration rates, however such measures are hard to make. Similarly post operatively many patients find exercise regimes hard to follow, may fail to progress, or over exercise. The product concept Enztec has developed involves the use of inertial sensors and a biomechanical model to create patient education, motivational and compliance monitoring tools that can be used by both surgeons and patients alike.
While wearable products are becoming more common, and biomechanical models and inertial tracking systems can be achieved, Enztec has not identified any competitor system that ties together rehabilitation considerations with such systems. Also many such systems require significant capital investment and large patient tracking rigs.

Project Brief/Objectives:

1. Become familiar with and select an inertial sensing system for purchase.
2. Develop a biomechanical model of one or both lower limbs, which can mimic (real time) the motions recorded by the inertial sensors
3. Create a GUI that shows the required motion and feedbacks of patients motion as a comparison
4. Create a means to measure joint acceleration rates in a clinical setting

Key questions for the project to answer:

A. Which sensor system is appropriate for the task, can the system ultimately be a consumable level hardware
B. What sort of real time data can be linked to a biomechanical model, and what is the latency of the system
C. Can a graphic feedback system be used to direct patient movements through a range of basic leg exercises
D. Determine types of exercise quantifiable measures are clinically useful and able to be measured

Key measurements would be:

i. Develop a linked biomechanical/sensor model
ii. Determine what latency and resolution can be achieved,
iii. Ability to demonstrate tracked patient movements, and red/green indication of desired movement boundaries.
iv. Describe required computation power required in the realised system (tablet, mini-PC, full PC) and optimal hardware

Project Scope

1. Research sensors inertial sensors that are commercially available
2. Research and select a biomechanical model for the lower limb(s)
3. Link the sensors and lower limb model
4. Demonstrate graphically or by numerical real-time data when a patient has reached a desired ROM (flexion/extension of knee)
5. Demonstrate an ability to measure joint movement data such as joint acceleration rates

Fields of Interest:

- Biomechanics, and patient rehabilitation
- Inertial sensing
- Embedded Systems and Coding

E05: Wind Farm Step Up Transformer Design Considerations

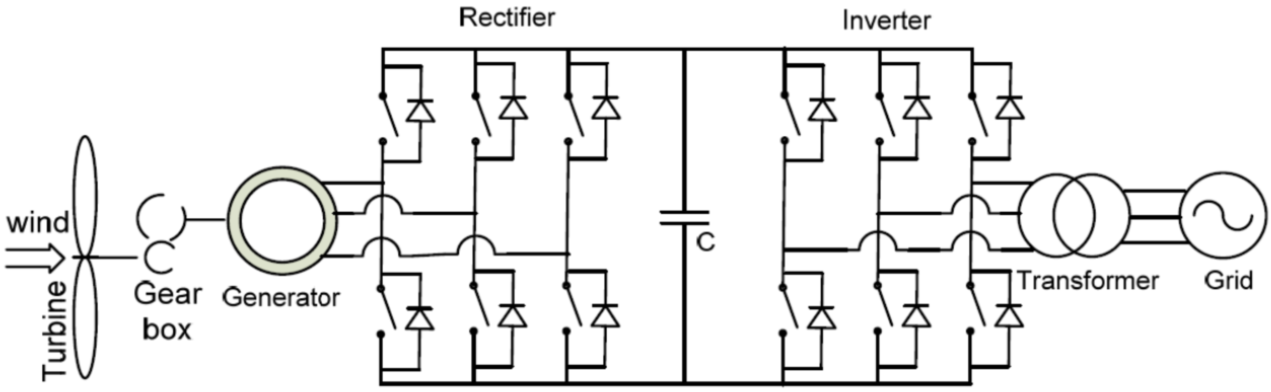
Sponsor: ETEL

Project:

1. Investigate effect of harmonics introduced by type 4 wind turbine generator

Wind turbine transformers must be properly designed to handle the failures caused by harmonics. Many wind energy technologies use converters to provide 50 Hz power to the collector system. These converters create harmonics of varying levels that result in harmonic currents flowing through the wind turbine transformers from the converters to the collector system. During the early development of these wind farms as converters started to replace simple induction generators, transformer specifications for these converter technologies did not always consider the harmonic loading of the transformers. The harmonics lead to eddy current and stray losses, which causes additional temperature rise. If wind turbine transformers are not properly designed to handle these harmonics, it would lead insulation deterioration. Cumulative effects are short life span and premature failure.

a) Model Type 4 wind turbine converter and investigate amount of harmonics and inter-harmonics that is seen by the step-up transformer.



b) Investigate transformer kVA capacity derating due to harmonics and loss of transformer life under effect of harmonics.

2. Investigate overvoltage on transformer due to single phase to ground fault on LV and HV side of step up transformer.

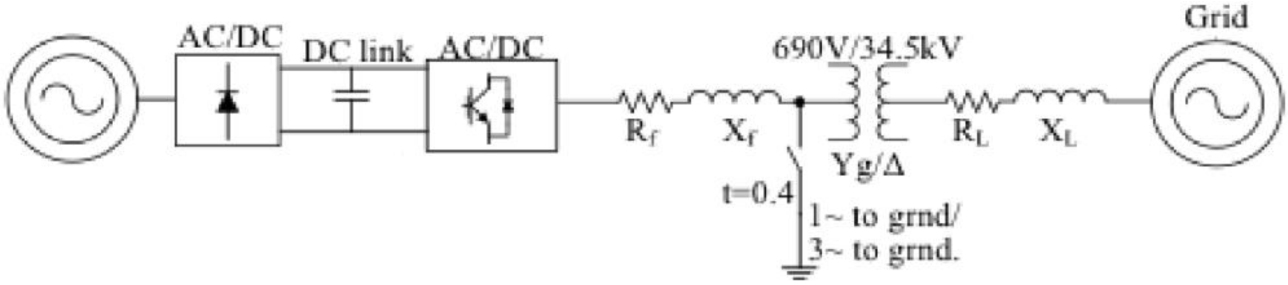
Wind farms by the nature of their design and operating characteristics are susceptible to a variety of overvoltages. Hence it is always important to conduct studies and tests of the various levels of overvoltages and how the equipment at the wind farm are able to withstand with or without mitigation measures.

Types of Overvoltages

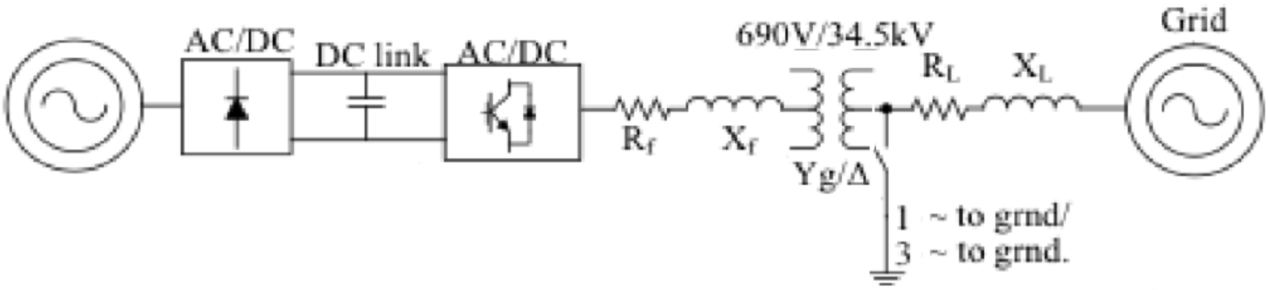
- Transient overvoltage – short-duration highly damped, oscillatory or non-oscillatory overvoltage, having a duration of a few milliseconds or less. Can be due to lightning, switching, and very fast front surges. Equipment withstand capability are specified as Basic Lightning Impulse Insulation Level (BIL) and Basic Switching Impulse Insulation Level (BSL).
- Temporary overvoltage – Oscillatory phase-to-ground or phase-to-phase overvoltage of relatively long duration (seconds to minutes) and that is damped or weakly damped. Due to switching or fault clearing operations, and includes events such as load rejection, and faults on high-resistance or ungrounded systems. May also occur due to non-linearities such as harmonics and ferroresonance.
- Ground Fault overvoltage – a specific form of temporary overvoltage that occurs in three-phase ungrounded or high-impedance grounded systems.

ETEL would like to investigate Ground Fault overvoltage in the following cases:

a) Fault on LV side



b) Fault on HV side



ETEL would like to know if insulation deterioration is caused by Ground Fault overvoltage.

E06: Seed Eating Bird Scaring Using a Programmed Drone

Sponsor: Functional Whole Foods

Introduction: *I am a mixed cropping farmer and my main crop is linseed to supply my linseed oil factory. I have worked as a research scientist in Agriculture for 20 years. Linseed is very attractive to birds. There currently no effective bird control techniques for keeping birds off seed crops, other than netting. The birds very quickly get accustomed to noise generating devices. The flocks grow in size very rapidly from day to day as somehow the message gets out that there is good safe feed available.*

The bird flock always have "scout" birds flying the crop. When these birds flutter down into the crop to feed the white underside of their wings can be seen from 600 metres away. As soon as the scout birds have settled the whole flock comes in to feed. Predator birds such as the Harrier hawk or the NZ falcon are very effective at frightening the birds away.

I believe a drone equipped with suitable movement sensors and programmed to randomly fly the paddocks (20 ha) until it detects bird movement and then follow the movement to the edge of the crop would be a very effective deterrent for resident flock and would minimise recruitment from outside the area.

Project Objectives

The project should have achievable deliverables, with technical breadth so that each student has a distinct role in the team. Also a technical stretch is desirable to allow a good student team to extend the boundaries if time allows.

1	Programme a drone to automatically and randomly fly a fixed area defined by GPS or corner beacons
2	Find/develop a movement sensor which is capable of detecting the presence of small birds and which can direct the drone to follow the movement to the boundary
3	Programme a drone to fly within height constraints so that it can gain approval to operate within Civil Aviation Authority Rule 102
4	Determine optimum frequency of use to effectively move birds off the crop.

Key questions for the project to answer:

a	What is the optimum way to define the area to be patrolled?
b	How far away can the available sensors detect small bird presence
c	What is the optimum way to define the height constraints which will effectively move birds on.
d	How quickly do birds become accustomed to drone scaring.

Key measurements would be:

i	Can a drone reliably fly automatically for the length of the available flight time and successfully land back at a base for refuelling/recharging.
ii	How far away can the available sensors reliably detect small bird presence and direct the drone to follow.
iii	Gain Civil Aviation Authority approval to operate a drone in such a way.
iv	What is that maximum flock size which will develop with the use of such technology.
Project Scope	
1	Is it feasible to effectively patrol 20 ha with a single drone or are more needed
2	There will normally be large birds such as the Harrier Hawk flying – is it feasible to not harass beneficial birds as well?
3	I suspect that flying low will be more effective at moving birds, but will also need to avoid things like fences.
4	How effective is the technology at: • moving birds already feeding regularly on a crop • preventing recruitment of new bird from outside the normal range How early would it have to be deployed to be effective

Fields of expertise:

Embedded Systems.

Movement sensor technology

Height control technology

E07: Commissioning of HiCEV (High Country Electric Vehicle)

Sponsor: Glenthorne High Country Station

Introduction:

In 2013 an ambitious High Country electric vehicle development project was initiated by Glenthorne Station in collaboration with the Department of Electrical and Computer Engineering – and so the HiCEV concept was born. From the outset, the primary goal for HiCEV would be for it to have the ability to perform all tasks the vehicle was able to carry out in its original conventionally powered form. This includes fording rivers, climbing steep gradients while carrying a load typical of a high country station, and being road-legal.

A Masters project has brought together the main power train elements (motor, motor driver, motor controller, batteries, and donor vehicle – a 70 series Toyota Land Cruiser). In 2014, a group Final Year Project was also completed which developed and built the auxiliary systems (power steering, power brakes, motor/driver cooling, cab heating, instrumentation panel, and CAN bus network). In 2015, a second Final Year Project Group completed additional systems integration associated with the CAN bus, battery management system, battery charging system, and auxiliary range extender.

Now that HiCEV is rolling under its own power, it requires passage through its warrant of fitness, operational testing, monitoring, troubleshooting, and optimisation. This will be the basis of this new Final Year Project.

Project Brief/Objectives:

1. Finalise the battery charging and management systems such that HiCEV is able to be simply plugged into a 12A mains socket, and is capable of connecting to the auxiliary power supply for range extending charging.
2. Finalise power steering, motor cooling, inverter cooling, power braking, and low voltage bus systems such that they are fit for purpose.
3. Finalise motor characterisation, and controller/system management unit parameter settings.
4. Finalise instrumentation panel, and cabin heater systems.

Key questions for the project to answer:

a. Is HiCEV able to be charged in a simple and repeatable manner while maintaining cell balancing and is the range extending power supply able to be used for that purpose?
b. Do the power steering, cooling, power braking, and low voltage bus systems all function sufficiently to allow for HiCEV to perform its normal on-farm tasks?
c. Is the power train system optimised for on-farm use?
d. Is the cabin heater functioning such that the vehicle operator has simple/normal control of cabin heating (along with the pre-heat function), and is the instrumentation panel functioning normally?

Key measurements would be:

i. Battery SoC is known at all times, mains socket current does not exceed 10A, and auxiliary supply is providing nominal current when used.
ii. All system currents are within nominal levels at all expected operational conditions, and audible noise is within acceptable levels.
iii. Motor torque is maximised for bus voltage conditions, and regenerative braking both mirrors conventional motor braking and is variable/maximised under braking conditions.
iv. Cabin temperature can be set (within tolerable variability), and the pre-heat function can be time and temperature set.

Project Scope:

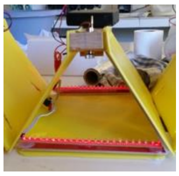
1. Review battery charger, BMS, and auxiliary power supply systems, research standards requirements, design and construct enclosures, couplings, etc., and confirm operation in range of farm conditions.
2. Review steering, cooling, braking, and LV auxiliary systems, and ensure functional operation is sufficient for farm use (including audible noise levels).
3. Review power train management system and optimise control parameters to make best use of motor, battery, and transmission capabilities.
4. Review instrument panel and cabin heater systems, and develop pre-heating algorithms and in-cabin manual heat controls.

Fields of interest:

- Electric vehicles.
- Electronics hardware (especially for Objectives 2 and 4).
- Embedded systems (especially for Objective 4).
- Power electronics/systems (especially for Objectives 1, 2, and 4).
- Control, electrical and mechanical systems/power (especially Objective 3).
- All Objectives involve some degree of CAN bus communications.

E08: Development of an Autonomous Insect Trap

Sponsor: Plant & Food Research



	Introduction
	Our Biosecurity group at Plant and Food Research in Lincoln has acquired funding to develop new digital tools for the detection of flying insects for the early interception of biosecurity threats in New Zealand. We are designing new digital tools that can detect the wing-beat frequency of insects via optoelectronic sensors (infrared light) and storing this data as audio for easy analysis. We have international collaboration with the machine learning team from University of California Riverside who provide support in data processing. We are also interested in carrying work with the LIDAR technology to localize insects in the landscape. The FYP team's role will include assisting our team in the improvement of acoustic trap prototype, collecting data and processing it. This will appeal to students with knowledge of modelling/machine learning algorithms and optical or acoustic engineering. The team will have some freedom to improve the current set-up and integrate a stand-alone power system for remote operation as well as wireless system to send the data automatically. The system is built around the Intel Edison microcomputer so some knowledge of Linux (Yocto or ublinux specifically) as well as an understanding of either C++ or python would be helpful.
	Project Brief/Objectives
1	development of a field deployable unit to detect insects by wing-beat frequency
2	collecting and processing of data
3	improve the optical and acoustic measurement techniques
4	integrate self-powered source of energy
5	integrate a wireless system to send the data automatically
	Key questions for the project to answer:
a	Can the performance of the sensors be improved and how?
b	Can the machine learning algorithm automatically collect and analyse the data to increase power of insect species identification prediction?
c	What is the best form of stand-alone power system for this aplication and what are its key requirements?
d	What is the most suitable wireless communication system?
	Key measurements would be:
i	digitally count and identify insect species from sound recordings
ii	correctly predict species from recordings
iii	measurements of power source requirements and duration of autonomy in the field
iv	remote acquisition of data
	Project Scope
1	Research best acoustic/light sensors to minimize noise and increase sensitivity of insect wing-beat frequency recordings under various field conditions
2	Train the machine learning algorithm with data collection in order to refine the power of prediction of species identification based on sound frequency and other environmental parameters specific to an insect species
3	Add stand-alone power system (e.g. solar) sufficient to allow the trap to collect data constantly for several weeks, months.
4	Research and develop wireless remote data collection system through network provider and web-app development
	Fields of Interest:
	· Acoustic sensors, light detectors, Machine learning, classification and prediction
	· Precision Agriculture, remote detection, Smart Trap, wireless sensor network

E09: FSAE Electronic Control of Electric Racecar Dynamics

Sponsor: Rodin Cars

Background Formula SAE is an international race car design and build competition. UCM (University of Canterbury Motorsport) are a top contender and by far the fastest improving team in the world. The team are changing to an electric powertrain system this year, using motors in each of the wheels. This powertrain opens up many opportunities to improve the vehicle performance with a smart control system that monitors various input sensors and changes the motor load in any of the wheels accordingly. If successful the result will be a car that can accelerate faster, be able to change direction faster, and be easier to drive fast and consistently. The project has the potential to make a very fast race car into a winning race car.

Project Objectives

Objective 1: *Research and understand the aspects of vehicle dynamics that are relevant to this project. Determine what data acquisition and control strategies are appropriate to achieve the desired results. Hint: there are many more types of data than there are types of useful data!*

Objective 2: *Design and manufacture the embedded control system that will link the input data with the motor control inverter. Write software to implement control strategies, which will include traction control, launch control, active yaw control (aka torque vectoring), electronic differential. There may be multiple strategies for each of these.*

Objective 3: *Test and develop the control systems on the actual car. The goal is to understand what works and why it works (collect data to show). Human factors are a major consideration here, as the best engineered system in the world is useless if the driver struggles with it. The electronics must also be tested to prove their physical robustness in an environment that is hot, subject to shock loads and vibration, and potentially wet.*

Areas of Interest Embedded control systems and software, SCADA strategies and implementation, PCB design & manufacture, electronics design for harsh environments, project management, teamwork and team based competition.

Further Reading www.facebook.com/UCMFSAE www.ucmotorsport.com

E10: Fault Location in 11kV Distribution Networks

Sponsor: SenSys Ltd

Introduction

SenSys develops remote sensing, processing and communication technology for environmental monitoring, status reporting, and actuation. They are active in many fields and are keen to expand their application space into support for electric power distribution companies. A significant issue that distribution companies face is locating faults within their networks. Most faults occur somewhere on a line, and usually manifest themselves as an overcurrent back at the substation, which is cleared by the protection systems. These typically yield little to no information about where the fault is, and finding repetitive or incipient faults can take a significant resource. The SenSys hardware could provide sensing and smart signal processing at locations down an 11kV feeder, to substantially decrease the time taken to find and repair the damage, or even help locate damaged equipment before a fault develops. The aim of this project is to firstly model a typical distribution network, apply a range of faults, and capture typical waveforms. Secondly some signal processing must be applied to recognize the type of fault that has occurred, and its approximate location. Preliminary work done in this area shows that the frequency and phase angle of transient oscillations can provide useful information about fault type and location.

Project Brief/Objectives

1 Develop and update a typical solidly earthed lines company distribution feeder model. Establish measurements at key locations within the feeder structure, and typify waveforms for a range of different fault types, locations and measurement locations.

2 Repeat the model and measurements for a resonant neutral earthed system.

3 Use transient-based system identification methods to extract key information from system waveforms.

4 Use the same system identification methods on real system fault waveforms.

Key questions for the project to answer:

a Can cheaply measurable voltage and current wave-shapes provide useful information about electrical distribution feeder faults?

b Which fault types are easily identifiable, and which aren't?

c Can system identification based analysis methods reliably extract useful information?

d Is the location of the measured waveforms a key factor in the reliability of fault identification and location?

e What information is needed about the distribution network to correlate waveshapes with fault location?

Key measurements of project success would be:

i. Generation and explanation of sets of fault transient waveform data for a typical solidly earthed 11kV distribution network

ii. The same for a resonant neutral earthed system

iii. Successful extraction of key waveform data (i.e. resonant frequency phase and damping)

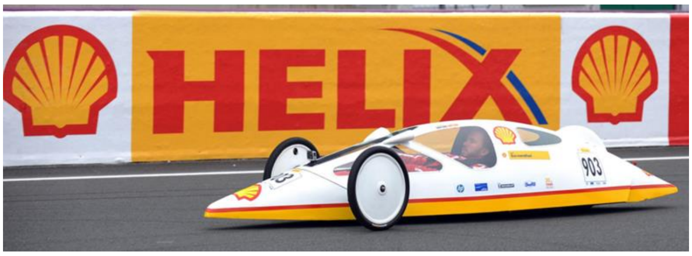
iv. Correlation of key waveform data with fault location and type.

v. Application of signal processing method to real data.

Fields of Interest:

- Electric power system modeling and simulation
- Signal processing and system identification

E11: Shell Eco-Marathon Efficient Electric Vehicle



Sponsor: Shell

Energy efficiency, embedded systems, motor control design, battery technology

Introduction: Shell Eco-marathon can trace its roots back to 1939 and a friendly bet between scientists at a Shell research facility in Illinois, USA, as to who could drive their own car the furthest on a gallon of fuel. From these humble origins, the worlds largest vehicle efficiency competition evolved and moved to Europe, the US and finally Asia.

Eco-marathon brings together future innovators and people who are passionate about the energy challenge, and asks them to think about sustainable solutions. It celebrates innovative thinking, the best up and coming engineers, designers and inventors, and cutting edge thinking about energy and mobility.

Every year students from universities across Asia come together in a unique four day event, to showcase, test and drive their ultra energy-efficient cars on real city streets. In 2015 over 120 student teams from Asia, Australia, the Middle East and Africa participated. A New Zealand team has never competed... until now!

We will design and manufacture a car for the electric competition category over the next year as a collaboration between two final year project teams, one from electrical engineering and one from mechanical. The team will cooperate and share resources with UCM, who are our students already successfully building race cars for the FSAE competition.

Our students will take their car to the Singapore competition in March 2017 to show the world what the kiwis can do.

Project Brief/Objectives

1. Research and understand the competition. Develop a concept for the electric powertrain and associated control systems which reflects your understanding of the system efficiency and compliance with the rules.
2. Design the electric powertrain - note specifically that the rules require the students must design and build their own motor controller.
3. Source, manufacture, and assemble the power train components into a functional system.
4. Test and develop the powertrain, measure the efficiency and understand where losses occur.
5. Compete with the car in the Asian Shell Eco-Marathon event, Singapore, March 2017.

Fields of Interest:

- Energy effiency and sustainability
- Mobility and transport from a design perspective
- Embedded systems design related to electric motor control
- Battery technology and battery management implementation
- Electrical/mechanical system integration and development

E12: Low Power Long Range Communications for Wireless Internet of Things Applications

Sponsor: Tait Communications

<u>Introduction</u>

This project provides opportunities to explore the exciting technology of the Internet of Things (IoT), a key element of the future internet, where almost anything may be connected to the internet. Technology companies around the world are working to turn this vision into a reality, and this project will be supported by Tait Communications. Tait is amongst the world leaders in the land mobile radio (LMR) market – supporting professional radio users such as emergency services, utility and transport operators with high reliability wireless voice and radio capability. Wireless IoT technologies represent an enormous opportunity for Tait. In this project you will analyse the Low Power Wide Area (LPWA) wireless technologies to help assess their suitability for selected professional applications through a written report, practical demonstrations and presentations. You will develop an over-the-air prototype using the latest LPWA development kits, remote sensors, cloud technologies and mobile device applications. You will work side-by-side with Tait's R&D team, and you will have the opportunity to demonstrate your prototype at Tait.

<u>Project Objectives</u>

The project should have achievable deliverables, with technical breadth so that each student has a distinct role in the team. Also a technical stretch is desirable to allow a good student team to extend the boundaries if time allows.
Note – it will be up to the student team to partition the tasks between themselves. Some tasks are achievable individually. Others may require input from multiple students.

1	Technology survey: LPWA is a technology designed for long range operation whilst maintaining a very long terminal battery life. There are a number of technologies in this space and the first activity is to undertake a review of the technologies available.
2	Establish a trial system using the chosen LPWA technology (most likely LoRa) comprising one base station unit and at least two terminal units. Both base station and terminals can be paired with an ARM processing board to enable interfacing and possible application work.
3	Using the trial system: establish a method of measuring and plotting error rates over a range of conditions (eg SNR), …
4	If practical, deploy the system at the university to monitor at least two points. One may include a simple status such as door open/closed. The other can be an analog sensor such as temperature.
5	Create a back office application to periodically read the status of the sensors and show the status on a map. In other words this application represents a simple monitoring application which LoRa is intended for. This application may be cloud enabled.
6	Using the trial system described above, with a separate terminal create a simple back office application to send paging messages to the mobile terminal end. At the terminal end, present the information on a connected smart device. On the smart device there shall also be a button to enable the user to confirm manually she/he has read the message. Such acknowledgement to be confirmed on the back office.

Key questions for the project to answer: *(The deliverables here are analytical / conclusions)*	
a	Assess the practical operation and performance of selected LPWA technology and report these findings to Tait in the form of report, demo and presentation.
b	Assess the suitability of the LPWA technology for selected applications and report these finding to Tait in the form of report, demo and presentation.
c	
d	
Key measurements would be: *(we suggest at least one KPI for each key objective)*	
i	Quality and depth of technology survey
ii	A fully functional system with good design, implementation and documentation
iii	Extensive performance evaluation of the LPWA technology
iv	Demonstration of example application to industry partner (Tait) & possibly 3rd parties.
v	Final report quality
Project Scope *(use this section to minimise barriers, add boundaries, steps or examples)*	
1	LoRaWAN source code and related tools are available online
2	Hardware will be provided by WRC (Wireless Research Centre)
3	Supervisors are from Tait company, ECE Department and WRC
4	Project will use the Agile/Scrum approach

Fields of expertise: *(use this section to identify key expertise/equipment needed to solve the problem)*

Students with keen interest in the future internet and IoT technology

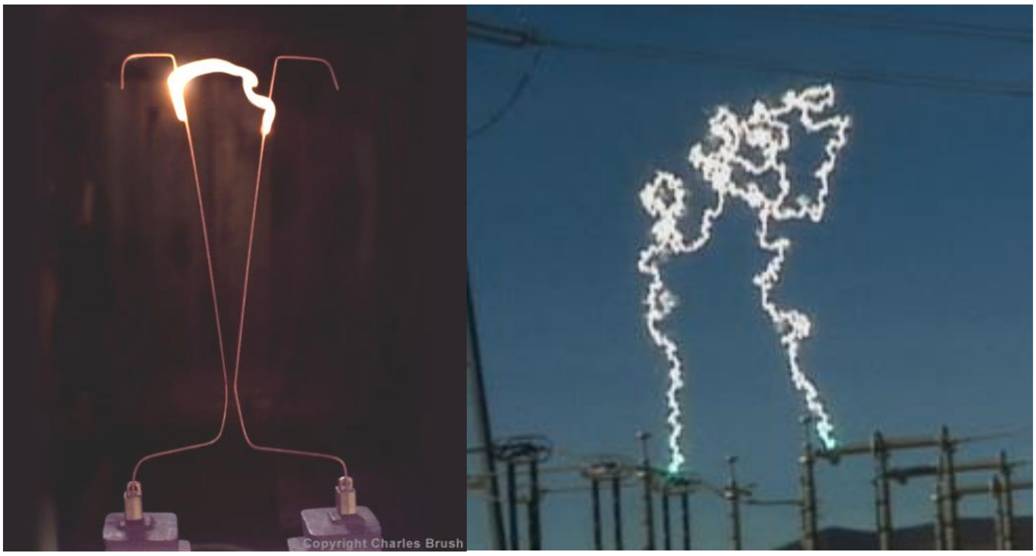
Some knowledge of wireless communications is required – modulation, basic channel understanding, BER/packet error rate performance evaluation.

Ability to work with a wireless hardware development system to build a working prototype, including system integration and testing with lab test equipment (CROs, etc.)

Experience in suitable programming skills including embedded/high level programming to build applications on mobile platforms (iOS or Android phone or tablet).

E13: Building a Giant Jacob's Ladder

Sponsor: Technix Industries Ltd



Research, engineering design, prototyping and testing of electrical and mechanical systems

Introduction

A Jacob's ladder is an electrical phenomenon that involves creating an arc which climbs between two vertical electrodes. Small scale demonstrations of this phenomenon have been carried out in the High Voltage Lab at UC. John Matthews from Technix Industries, a research and technology company, has the vision to realise a giant version of the Jacob's ladder to create a mind blowing exhibition for private and public viewing, "the bigger the better". This project would involve investigating and quantifying aspects of the phenomena in a Jacob's ladder to determine the maximum feasible size at which it could be created and to build a demonstration model (as large as practical within the year).

It is proposed that the vertical electrodes of the ladder could be lightweight cables suspended from buoyant balloons to create a ladder of >100m. This project has two design aspects critical to its completion; the electrical system design (high voltage circuit to create the arc) and the mechanical system design (system for providing the vertical electrodes), therefore, **the project would suit a mix of electrical and mechanical students.**

Project Brief/Deliverables

-Investigate the phenomenon of the Jacob's ladder to determine critical aspects of its function that will affect the maximum height and width achievable.

-Identify the requirements of the electrical system as the size of the Ladder increases and scope the system for the giant size.

-Develop the mechanical design for the system to maintain the position of the vertical electrodes and scope the required material and mechanical components.

-Build a large scale version (not necessarily the giant size) of the electrical and mechanical systems suitable to validate the proposed concepts and demonstrate the intended exhibition.

Key questions for the project to answer

-What is largest feasible size that the Jacob's ladder can be created using currently existing materials and technology?

-What is the estimated cost for building the giant Jacob's ladder?

Key measurements would be:

What are the electrical system requirements for the largest size Jacob's ladder?

-What are the geometric (electrode position) and environmental limits (wind/rain) at which the phenomenon will still occur?

-What is the most suitable material for creating the electrodes?

Project Scope:

-Quantify the effects of conductor position geometry (how wide and how parallel), material requirements (conductivity) and environmental conditions (wind speed, humidity) on the performance of the arc.

-Conceptualise a method of positioning the electrodes within geometric requirements to facilitate the climbing arc and build a prototype.

-Investigate AC and DC arcs for a Jacob's ladder to determine the most suitable arc for increasing the size and for its aesthetics values. Identify any novel effects that can be created for the rising arc i.e. arc colour due to electrode material.

- Identify electrical and mechanical safety considerations of the exhibition.

Video of a demonstration of the Jacob's ladder and example of the scale of arc desired in the giant version:

https://www.youtube.com/watch?v=vOYy5NZ4hWA

https://www.youtube.com/watch?v=vqgNrj6oEdc

Fields of Interest:

High voltage electrical system design, mechanical engineering design, prototyping, testing

E14: Effect of Regional Photovoltaic Installations on the National Grid

Sponsor: Transpower Ltd

Introduction

As the national power transmission system operator, TransPower needs to keep a watch on new technologies as they come into New Zealand. One of these technologies is Photovoltaic (PV) power, which is experiencing a small but rapidly increasing uptake amongst domestic households around New Zealand. Already in Australia power generation is dominated by domestic solar installations during summer daytime. If this were to occur in New Zealand, power flows could be significantly affected. This project involves an investigation into the likely effect of PV on national power flows, in particular in the short-term (minutes to hours) as irradiance varies across the country. It will involve modeling of loads, solar radiation, and at various levels of PV penetration will involve system studies of real and reactive power flows and voltage levels around the country. This project is associated with GREEN Grid, a research project investigating issues associated with higher levels of renewable generation in New Zealand. GREEN Grid will be a significant source of data for this project.

Project Brief/Objectives

1 Gather and model load and generation data for all New Zealand grid exit points.
2 Gather and clean sunshine data for locations around NZ grid exit points.
3 Transfer sunshine data to generated power data for PV installations
4 Establish credible PV uptake scenarios.
5 Identify a suitable power flow/transient analysis package, and run multiple simulations to establish effects on National grid. This may include power flows, and the effect of PV system disconnection and reconnection to the grid following system faults.

Key questions for the project to answer:

a Are Photovoltaic installations likely to affect power flows in the national grid, and over what time spans are the affects likely to occur (hours, days or years)?
b Are Photovoltaic installations likely to affect system robustness against faults, particularly during fault recovery?
c What is a suitable way of understanding and visualising the temporal variability introduced by photovoltaic solar power and the resulting geographic variability?
d What is a suitable modeling methodology for system planning?
e Should inverter standards be changed to enhance grid robustness?

Key measurements of project success would be:

i. Generation and visualization of changed power flows
ii. Characterisation of the effect of existing inverter behavior on grid resilience against faults.
iii. Demonstration of modeling methodology for future use
iv. Prediction of PV uptake levels that could cause issues.

Fields of Interest:

· Electric power system modeling and simulation

E15: Tethered UAV

Sponsor: Trimble - Caterpillar

Electronic Design, Mechanical Design, Control Systems

Introduction

Trimble, in partnership with Caterpillar, develops products related to positioning on construction sites. UAVs offer innovative capabilities for remote sensing. Some applications require full-time aerial operation, so a tethered UAV avoids reliance on battery power. A previous project investigated this concept and built a prototype. The goal of this 2016 project is to continue this work, improving the power electronics, implementing autonomous control, implementing a tether winch, and evaluating flight envelope and platform stability.

Project Scope

There are now commercial tethered UAV products available, but they are expensive. The intention of the project is not just to explore more cost-effective implementation options, but also to evaluate the suitability of the concept for specific use cases.

Relative positioning (with respect to the base unit) is crucial to a working product. Trimble will assist by supplying two GPS receivers and associated equipment. The Trimble sensor payload is outside the scope of this project, but will weigh 0.8 to 1.5kg. For the purposes of this project, the GPS hardware can be considered as part of that payload mass.

The scope includes utilising the relative positioning data as input to a control system, aiming to hover the UAV over the base unit. In some scenarios the base unit will not be stationary.

Project Objectives

ME/MT: Design & prototyping of a base unit, including

- Motor/winch/fleet angle compensation
- Method for measuring and maintaining line tension
- Slip ring or similar to supply power as drum rotates

EE/MT:

- Implementing electronics and firmware to automatically control the winch operation
- Complete the design and implementation of the airborne power system, in particular to handle motor startup conditions, UAV battery charge/discharge
- Change to a better autopilot software, which probably requires a new autopilot board. The current Tau Labs software's hexacopter implementation is buggy.
- Implement autonomous flight control:
    - Launch and land operations on command
    - Continuous operation, maintaining vertical offset over a stationary base unit
    - Continuous operation, maintaining a fore/aft offset from a moving base unit

Flight Testing

- Maximum speed (approximates to maximum wind speed), with estimation of tilt angle at that speed
- Maximum acceleration, as expected during wind gusts and machine startup/reversing/turning
- The TUAV's primary purpose is to be a camera platform, so attitude, stability and vibration needs to be measured in typical operational conditions. This requires logging pitch/roll/yaw, image processing, or both, during various maneuvers.

E16: Automatic System Counting Inventory of Logs in a Log Yard

Sponsor: Tui Technology

Image capture, analysis and testing

Introduction

Tui Technology is a leading electrical engineering and automation solution supplier to industry in New Zealand and Australia including sawmilling, printing and packaging, steel pipe fabrication and food industries. Our special skill is in getting the best out of machinery and people. We have a particular focus on finding the right technology for the job. Our toolbox includes motion control, laser scanning, PLC design, safety engineering, CAD design, specialist microcontroller applications, PC software and mobile data communications.

Project Brief/Objectives

1 Assess different methods of capturing and analysing images of logs in a yard
2 Select the best method of capture a strategy to automatically calculate the number of logs
3 If a commercial (OTS) system appears to be capable of sufficient accuracy, robustness and programmability to deal with dirty random logs, then develop a testing strategy using that system as a benchmark to be improved on where possible
4 Perform the testing on a number of sites with the most diverse range of conditions and put in place strategies to deal with the problems which usually arise
5 If a dedicated system is required, prepare a scope for that to either be performed as a part of this project; otherwise refine the OTS system to optimise its performance

Key questions for the project to answer:

a Which will suit this project better... A new proof of concept system, or an upgraded/optimised OTS system
b What is the largest sample of logs which can be counted from a single image
c How will a whole yard of logs be counted without any sampling errors or omissions
d Can a series of fixed cameras be used to provide a running count at all times
e Scanning alternatives

Key measurements would be:

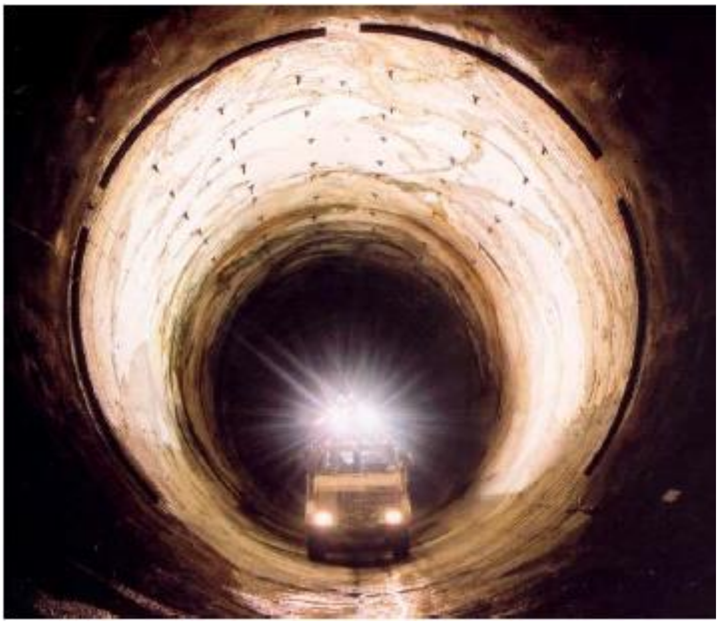
I Maximum count per camera
Ii Statistical accuracy for a given range of log conditions
Iii Optimum placement or use of cameras

Fields of Interest:

Computer vision
Image processing
Counting systems, inventory control

M01: Manapouri Tailrace Tunnel Underwater Inspection Vehicle
(Department of Mechanical Engineering supervised and assessed project)

Sponsor: Meridian Energy



Manapouri Power Station is located in Fiordland National Park, and has the country's largest installed hydropower capacity of 830 MW. The station takes up to 550 cumecs of water from Lake Manapouri to an underground powerhouse, and then via two tailrace 10 km tunnels to Deep Cove.
The tailrace tunnels should be inspected occasionally to check that the tunnels' lining is in good condition.
However, it is extremely difficult and expensive to dewater the tunnels to perform an inspection, especially since a whole-station outage is required.
There would be considerable value in an unmanned submarine vehicle that could perform a condition assessment of the tunnels with the station in normal operation.

Project Brief

1. Design an unmanned, autonomous, submarine vehicle that can survive a journey through the tunnel, record data on the way, and be retrieved at the other end.
2. Build and test a prototype.
3. Plan and perform a test run at Manapouri, and analyse the results.
4. Produce a report detailing the design, test, results and recommendations for future development work.

Challenges

The vehicle must be safely lowered and released into the tunnel via one of the underground maintenance shafts. It is most likely that the vehicle will end up in the second tailrace tunnel.

a. The water in the tunnel may be very turbulent, and the tunnel walls are hard Fiordland granite. The vehicle must be built to withstand the journey.
b. The vehicle should be neutrally buoyant to avoid rolling along the floor or roof of the tunnel.
c. It will take approximately an hour for the vehicle to wash through the 10 km tunnel.
d. The vehicle must be safely retrieved from a boat before it disappears out to sea, or sinks hundreds of metres into Deep Cove.
e. At least accelerometer and video data should be recorded, although no usable condition assessment of the tunnel is expected in this first year of the project.
f. The site is very isolated – accessible only by boat, a long way from Christchurch, limited cell phone coverage, and probably only one chance to get it right.

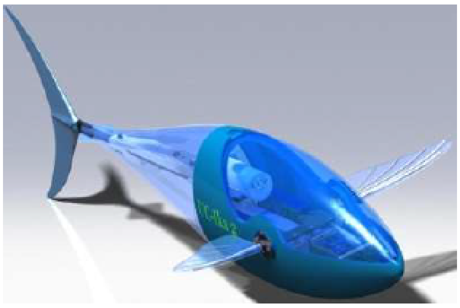
Key Outcomes

1. Design and build a prototype worthy of a test and Manapouri.
2. Successfully deploy and retrieve the vehicle.
3. Recover data about the vehicle's journey through the tunnel.

M02: Development of a Robotic Fish for Chemo-Photographic Observations in Coastal Waters (Department of Mechanical Engineering supervised and assessed project)

Sponsor: UC Dept of Biological Sciences

Introduction:



The coast is an area of transition between land and sea, and between freshwater and saltwater; unique to the Kaikoura coast is the rapid change in the ocean depth. Depth ranges from 10 m – 1000 m within just 500 m from the shore. Studying marine and coastal interactions in this system is challenging and the use of remotely operated vehicles is essential. However, these vehicles are often large and most suitable for use offshore, deployed from a ship. The aim of this project is to design a remote controlled vehicle that can be used in coastal waters and suitable to manoeuvring through rocky/stationary and soft/movable terrain.

Project Brief/Objectives:

1. Design a robot that can swim in coastal waters including turning and up and down manoeuvring.
2. Develop the robot to be remotely controlled from the surface, but to also sense bathymetric change in order to alter its path.
3. Investigate the effect of diving on the functioning of the robot to find its optimal working depth.
4. Add functional components to the robot that would allow miniaturised sensory and photographic equipment to be attached to, or within, the robot.

Key questions for the project to answer:

1. Can a robotic fish be used to collect data in coastal waters?
2. Can a robotic fish be designed to swim within a coastal rocky reef system, where the reef is comprised of ridges and gulleys, and where large seaweeds can tangle human swimmers?
3. What is the maximum depth at which we can expect a robotic fish to function?
4. Can correct swimming function be maintained with modifications for adding small sampling equipment to the surface, or within the body of the fish?

Project Scope:

1. Research suitable design concepts for general (straight, turning, up & down motion) and specific (rocky obstacles, seaweed) manoeuvrability of the robot.
2. Develop a working prototype and investigate ways to control the robot for the particular environment of coastal waters.
3. Research the effects of pressure change on the robotic structure and materials, and test the maximum and optimal depth at which the prototype could be used.
4. Research methods and equipment to detect chemical pollution in salt water and to visualise the environment. Modify the design of the robot to include such equipment.

Fields of Interest:

- Mechanical design, remote underwater vehicle
- Robotics
- Mechatronics
- Marine biology, fish anatomy, coastal ecosystems
- Remote sensing, bioassays

M03: Development of a Motorised Arm for a UAV (Department of Mechanical Engineering supervised and assessed project)

Sponsor: Britten Ltd

Introduction

Sam Britten (Britten Ltd) has devised a UAV camera system with expandability to perform a range of other tasks. There are numerous commercial opportunities for such a UAV and a modular approach will facilitate the easiest upgrade path for future developments. Where off-the-shelf solutions exist for propulsion, control, power, gimble... these will be utilised. The core design effort in this project will be on mechanical aspects as well as programming aspects to enable 2-axis control of an arm accessory.

Project Brief/Objectives

1 Devise a structured plan for the development of a detachable robotic arm with significantly more versatility than has been seen on a UAV until now
2 Select a suitable motor and gearbox system from a range of alternatives, which will become the basis of the mechanical design project
3 Select a suitable software development platform and architecture for the control of the arm in flight, via an iOS or Android app, taking into account IMU data received from the off-the-shelf system
4 Engineer the arm with a claw to perform a demonstration of picking up a light-bulb without crushing it
5 Integrate some other useful functionality if possible, such other kinds of arms, a charging landing pad

Key questions for the project to answer:

a Can this proof of concept version perform the light-bulb pick-up demonstration (for promotion)
b Can the drive system for the arm be improved upon in future through the use of other motor or gearbox technologies
c What will be the next function the arm will be able to perform (washing windows??)
d Can the sideways or forwards stability of the camera/arm be improved further
e Does the iOS/Android app perform fast enough to be adapted into a commercial version

Key measurements would be:

i time needed or number of attempts required to complete the light-bulb demo successfully
ii stability performance with 1 and/or 2 axis control of the arm and range of movement needed
iii durability of bayonette type modular arm attachment
iv ability of the software to cope with changes in frame of reference during large movements

Fields of Interest:

· Mechanical design, testing and control, MCAD
· UAV technology.
· Software control and interfacing with UAV systems