School of Aerospace, Mechanical and Mechatronic Engineering

Thesis/Capstone project topics.

2018 MECHATRONIC TOPICS
The aim of this project is to complete a 2D simulator to model the flight movements of a bird to allow us to test various different energy scavenging mechanisms prior to building a scavenging system that can be attached to a bird.

Jorja started the project in 2011 by developing a small accelerometer and data logger to measure the motion of pigeons in flight. She developed a rudimentary single axis mechanical simulator to quantify the effectiveness of energy scavenging systems. James extended the simulator to two axes.

**Research Proposal**

- Complete the development of a robust 2-axis bird flight simulator
- Investigate existing energy scavenging systems and select one that would be suitable to power a typical radio beacon and data logger attached to a bird
- Develop such a system and demonstrate on a vibration table that it could supply sufficient power
- Ethical approval has been obtained to test a data logger on a pigeon, and it is possible that this approval could be extended for tests of the scavenger

**Required Skills**

- Electronics
- Mechanical design (SolidWorks etc)
- Affinity for animals
Electronic devices to detect bat calls are fairly commonly available but generally quite expensive. Two different principles can be applied; the first is to down convert the ultrasonic signal to the audio range, and the second is to digitise and stretch the signal.

Research Proposal

- Investigate the different techniques used, and try to determine why these devices are so expensive
- Develop the electronics and the software to perform the function in a low cost manner
- Build into a robust battery powered device
- Travel around and record the calls of as many bats as you can

Required Skills

- Interest in bats
- Interest in analog electronics
- Microcontroller programming skills
- Signal Processing
Radiometry at 94GHz offers an excellent option for ground imaging during adverse weather or at dusk and dawn when visible and IR sensors suffer from poor performance.

**Research Proposal**

- A prototype scanner and radiometer has been built that operates at 94GHz
- A new mirror must be made using the 3D printer as the old one has drooped
- Both the scanner and the millimetre wave receiver hardware need to be hardened for installation in a UAV
- Interfaces to a microcontroller to read the radiometric signal, and the mirror position as well as any aircraft INS data that is available must be developed so that images can be produced
- Software to produce strip-map radiometric images from a moving aircraft must be written

**Required Skills**

- Communications and Interfaces
- Some understanding of RF
- Mechanical Design & SolidWorks
- Electronics
- Signal Processing
- C or C++ and MATLAB Programming
Development of a ground based sounding rocket tracking system

Supervisor: Graham Brooker, ACFR gbrooker@acfr.usyd.edu.au
(contact Jasper Brown for an introduction)

Research Proposal

Having external data to validate the on-board rocket telemetry is essential as most competitions have altitude targets. Development of a low cost and portable system to track the rocket location and altitude is the topic. Students would need to evaluate various approaches to this such as onboard strobes, radar reflectors, ground radar, ground visual tracking, beacon triangulation etc. to determine the most suitable system. They would then design, build and demonstrate this system on the rocket to validate the accuracy of the on-board telemetry.

A major component of undertaking this thesis topic under USYD Rocketry Team is to contribute to the construction of a rocket for the Intercollegiate Rocket Engineering Competition (IREC) which is held in America every year. The student will work together with other thesis students researching into other components of the same project.

For more information regarding the topic, please contact Liyong. For information regarding USYD Rocketry Team or IREC, please contact Joshua CM or Zoren Liu.

Required Skills

Interest in sensors
Mechanical and electronics skills
Good software skills
Drone based tracking of a sounding rocket

Supervisor:  Graham Brooker, ACFR gbrooker@acfr.usyd.edu.au 
(contact Jasper Brown for an introduction)

Research Proposal

Tracking the rocket touchdown location for retrieval is essential when using high altitude rockets, a drone could do this whilst also filming the rocket for flight analysis. Students would need to design and implement a descent tracking system (visual or otherwise) on a commercial drone. This should allow the drone to safely follow the rocket as it descends under parachute. A possible extension to this topic is drone tracking during the ascent phase where the drone will use maximum power to track the rocket for as long as possible, then reacquire it during descent.

A major component of undertaking this thesis topic under USYD Rocketry Team is to contribute to the construction of a rocket for the Intercollegiate Rocket Engineering Competition (IREC) which is held in America every year. The student will work together with thesis students researching into other components of the same project.

For more information regarding the topic, please contact Liyong. For information regarding USYD Rocketry Team or IREC, please contact Joshua CM or Zoren Liu

Required Skills

- Interest in sensors
- Mechanical and electronics skills
- Good software skills
Milk flow measurement for breastfeeding babies

Supervisors:  Graham Brooker, ACFR  gbrooker@acfr.usyd.edu.au
Sarah Tapp


The normal method to determine how much breast milk a baby has consumed is to measure their mass just prior and just after breast feeding. This is prone to error or expensive as low cost scales that can measure the mass of a baby to an accuracy of 1-2g tend to drift.

An alternative developed by an Israeli start-up is apparently to measure the milk content in the breast alveoli prior to and after feeding http://www.popsugar.com/moms/Milk-Sense-Breastfeeding-Measuring-System-31964673.

Research Proposal

- Develop an easy to apply soft sensor that fits around the nipple and measures milk flow in real time (magnetohydrodynamics, Doppler imaging, dielectric, conductivity etc)
- The device must communicate wirelessly to an app which displays and records the total milk output

Required Skills

- Some biology
- SolidWorks
- Interest in sensors
- Mechanical and electronics skills
Quantification of the forces exerted during operative vaginal delivery

Supervisors: Graham Brooker, ACFR gbrooker@acfr.usyd.edu.au
Dr Jon Hyett, RPAH jon@fetalmedicine.com
Sarah McDonald, RPAH smcd6737@uni.sydney.edu.au

A significant (10-15%) proportion of babies require assistance during the process of vaginal delivery. This involves application of either forceps or ventouse (vacuum), allowing the acoucher (the person who assists at a birth) to guide the presenting part through the birth canal, onto the perineum and through to delivery. Women and babies who have an operative vaginal delivery have higher risks of traumatic injury related to the delivery process. The forces involved in delivery are poorly understood. We hypothesize that injury would be more likely in circumstances where higher forces are developed during the delivery process. Real time measurement of these forces would provide the acoucher with information about the risks associated with delivery.

Research Proposal

This project involves the development of an instrument to quantify the forces exerted during operative vaginal delivery. The point of contact between the instrument and the acoucher (i.e. handle of instrument to gloves) is sterile, and this device needs to be able to be applied in this environment. The device should be able to quantify the amount of force and record the direction of force during the delivery process. The device will first be used in simulations of the birthing process, as proof of concept, prior to being applied to clinical studies.

Required Skills

- Some biology (or an interest in the subject)
- Electronics & sensing
- Mechanical design (SolidWorks)
- Signal processing
The use of simulation in medicine is becoming increasingly used to educate and train clinicians in a range of skills otherwise difficult to gain access to. Overall, simulators are becoming more realistic, unfortunately obstetrics birthing simulators are still unable to provide a simulation capable of training clinicians in some of the finer motor skills and techniques of delivery. This project originally focused on training clinicians in manual rotation. Aicha started the project by developing a Pneumatic Artificial Muscle (PAM) based simulator that actuated a foetal head. Ashan developed a tablet based interface and Sarah continued the project by developing the soft tissue interfaces and alternate sensing methods.

A greater need for a more accurate birthing simulator has now been identified and a completely revised system is required. The new system is to model the contraction of the uterus and corresponding forces on the uterus, the fetus and the birth canal.

**Research Proposal**

- Based on a human mannequin frame, develop a method to simulate the contraction of the uterus in such a way that will facilitate the expulsion of a model fetus through the birth canal and vagina.
- Develop a suitable model for the birth canal and the vagina that will provide an accurate interface for obstetricians and midwives practising manual rotation of the fetal head.
- Instrument the fetal head to identify forces imposed by the birth canal and also by fingers or forceps during manual intervention.

**Required Skills**

- Some biology
- Control
- SolidWorks
- Mechanical and electronics skills
Medical scan to 3D print

Supervisors: Graham Brooker, ACFR gbrooker@acfr.usyd.edu.au
Sarah McDonald, RPAH smcd6737@uni.sydney.edu.au

Maternal and fetal scans are used as key diagnostic tools during pregnancy. While scanning imagery and reconstruction tools have improved and provide a strong tool to assist clinicians in identifying and understanding problems that present there still exists a tangible gap. The ability to easily build a 3D tangible model within clinics presents a range of benefits for both research and clinical practice. Ultimately clinicians would be better able to visualise and explain any issues that present to patients and family in a way that may assist these patients further understanding why recommendations are made. Patients would then be in a better position to make an educated decision on whether they choose to accept the recommendations. Clinicians will be in a better position to best help patients regardless of their decision.

Research Proposal

- Identify materials and resolutions to best produce 3D replicas and corresponding printer
- Design an intuitive interface that can be operated by a nontechnical operator
- Develop a method of converting scan files into an object map ready for print
- Use the developed interface to action a print of a preselected area of the scan

Required Skills

Some biology (or interest in area)
SolidWorks/ 3D printing
Mechanical and software skills
Ultrasound Phased Array Imaging
Continuing project
Supervisor: Graham Brooker gbrooker@acfr.usyd.edu.au

The object of this thesis is the extended development of an ultrasound phased array imaging system. Previous work has provided core signal processing electronics and software algorithms for imaging. Advanced topics in signal processing and end applications are now possible.

Potential Research Areas

Signal Processing:
High fidelity coherent signal processing techniques:
  - synthetic aperture
  - coherent motion detection
  - multiple-pulse integration & fusion.

Applications:
  - Incorporation onto a mobile platform
  - 3D Volumetric visualisation methods
  - 3D Object analysis
  - Ground texture analysis

Required Skills

  - Communications and Interfaces
  - Electronics
  - Signal Processing
  - C or C++ and MATLAB Programming
Supervisor: Dr Andre Kyme (AMME Biomedical Engineering)

Contact
Dr Andre Kyme (AMME)
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T: 9351 2260

Project 2: A fast and reproducible multi degree-of-freedom robot manipulator for use inside an MRI scanner

Topic area: Biomedical, mechatronics

Project summary
Robots are superb for performing highly controlled and reproducible motion. This is essential for testing and benchmarking new motion corrected imaging methods, developing quality control procedures for motion-adaptive radiotherapy techniques, and enabling MRI-guided surgeries. Currently there are no robots available which can perform rapid, highly reproducible motion in multiple rotational and translational degrees-of-freedom within the high magnetic field of a MRI scanner. The aim of this project is to investigate suitable actuation approaches and robotic designs for the manipulation of phantoms in a 3T field, and to begin prototyping such a system.

Project 3: Development of a scalable 3D modeling tool using a 6-axis robot and computer vision

Topic area: Biomedical, mechatronics

Project Summary
Building 3D models of objects is a vital step in many engineering and biological applications. Such models can be reconstructed from a large number of 2D silhouettes of the object. Using a 6-axis robot, cameras and computer vision principles, you will develop the hardware and software tools to build a versatile modelling platform suitable for generating 3D object models over a wide range of scale and resolution. This project suits students with an interest in robotics, computer vision and programming.
Topic: “Machine vision analysis of harvested forestry sites using high-resolution UAV data”

Supervisor: Dr. Mitch Bryson (Australian Centre for Field Robotics)
(m.bryson@acfr.usyd.edu.au)

The Australian Centre for Field Robotics (ACFR) is involved in several projects with Australian and New Zealand plantation forestry industry partners that seek to develop new sensing and software tools for improving resource inventory activities. This project will involve the development of algorithms for building photomosaics and 3D surface models over post-harvest forestry sites using high-resolution imagery captured by a low-flying UAV. You will develop image processing and computer vision algorithms based on machine learning to detect, segment and quantify ground-cover at the site including coarse woody debris and tree stumps. This information is currently surveyed manually using team of people on the ground which is time-consuming and expensive. An automated system for performing this analysis will have a strong impact on the forestry industry by allowing data from the site to be checked against the actual harvested timber, and to plan for replanting.

Desired Skills:
- Programming: C, C++, python and/or MATLAB
- Some experience with image processing, computer vision or machine learning
Motion capture systems that can reconstruct the complete body pose (i.e. orientation and position of legs, arms, head and other joints of a person’s body) use various technologies; most commonly used systems involve an indoor setup with multiple cameras that observe and track artificial markers attached to a person’s body. This project would seek to develop a human-pose tracking/motion capture system based solely on a series of Inertial Measuring Units (IMUs) attached to a person’s body. Such a system therefore does not require externally visible markers to be worn and can potentially track a person’s motion in a variety of indoor and outdoor environments (does not need an external camera network). The potential applications for this system include art and entertainment (recording physical movements such as a dance performance), physiotherapy/rehabilitation (recording a patient’s progress in recovering mobility or sensing/recording pathologies in a patient’s movement or gait) and human-computer interaction.

Desired Skills:
- Programming: C/C++ and python/MATLAB
- Electronics: Microcontrollers and sensors
- Interest in mechanical design and/or 3D printing
More than 1% of the world’s population are unable to hear – many of these people use sign language as their primary means of communication. There are many different sign languages: in Australia, the Auslan system is used (http://www.auslan.org.au/).

This project would seek to develop a system for recognising Auslan hand gestures from a video stream using computer vision techniques that can translate or recognise basic sign language letters, numbers or words. Such a system would use real-time image processing techniques to detect and track the position of someone’s hands and face in a video stream, normalise the orientation of the hands and potentially the fingers, and to recognise certain gestures using a machine learning strategy. The translated words and phrases would then be presented to someone using the system in the form of text on a screen or to audio using a text-to-speech system.

Desired Skills:

- Programming: C/C++, python and/or MATLAB
- Some experience with image processing, computer vision or machine learning
- Willingness to learn (or basic knowledge of) sign language
Mapping Road Networks Using GPS Data

Supervisors: Konstantin Seiler, ACFR k.seiler@acfr.usyd.edu.au
Andrew Hill, ACFR andrew.hill@sydney.edu.au

Map services such as Google Maps have long been using vehicles’ GPS information to predict road conditions. While classic map services can assume a fixed, well known road network, on an open cut mine site, the roads are continuously changing to follow the site’s progress. Every few minutes, a small change to the roads happens somewhere on the site, making it hard to maintain an accurate road map manually. The aim of this project is to use GPS vehicle tracking information and terrain data to map the road network and/or update parts of an existing road map.

The work is expected to integrate with current research efforts on traffic optimisation within the mine sites. For this, highly accurate GPS data from vehicles on the site as well as 3D terrain information is available. This project entails working with fleet data from Rio Tinto’s iron ore mine sites. We have access to large amounts of positional data, both, historic and live, which will form the basis of this project.

The Rio Tinto Centre for Mine Automation (RTCMA) is a research group within the Australian Centre for Field Robotics (ACFR), whose vision is to fully automate remote mine operations in the Pilbara region of Western Australia. Our research areas include equipment automation, control and optimisation of industrial fleets of vehicles, sensing and perception of the environment, machine learning for geology and equipment modelling and data analytics. The research projects are supported by Rio Tinto, with several now operating in iron ore mines in Western Australia.

Required skills:
Programming (Matlab or Python)
Some SQL (or pick it up as you go)
4th Year Thesis Topics – 2018

Thesis Adviser: Dr. Ali Haydar GÖKTOĞAN

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Thesis Topics

1. Development of an Unmanned Autonomous Paramotor
2. Development of an Unmanned Autonomous Motorized Trike Hang Glider
3. Development of a Novel Multirotor UAV
4. Autonomous Landing of a VTOL UAV On a Moving Platform
5. Development of a Tethered UAV for Prolonged Flight Operations
6. Flight Characterisation of a Returning Boomerang
7. High-Speed Tracking System for Ground-to-Air Video Recording
8. Tile Bonding Analysis Using Impact Acoustics
9. Wall Climbing Robot
10. Autonomous Boat for Environmental Monitoring
11. Development of an Autonomous Forklift
12. Development of a Telepresence Robot
14. Path Planning and Control of a Microrobot Team
15. Vision Based Closed-Loop Control of Microrobots
16. Moving Microrobots in 3D Workspace Using Multiple Electromagnetic Coils

... and more ...

► Come and see me to discuss other thesis opportunities!
Development of an Unmanned Autonomous Paramotor

Paramotors are motorised paragliders. They offer one of the easiest forms of flying. For this thesis, you will be given an airfoil, a motor, remote control equipment and a set of sensors and a small-embedded microcontroller board to construct an Unmanned Autonomous Paramotor (UAP).

There is a significant body of knowledge about low-cost small flight controllers and UAP systems on the Internet as well as numerous open projects to learn from. For this project, initially, you will fly the UAP in manual radio control (RC) mode. After that, you will acquire flight data for the system identification. The characterisation of the UAP will help you to develop a set of flight control algorithms. Finally, you will demonstrate autonomous waypoint navigation, precision-landing operations.

If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the flight controller system.

**Required Skills:**
- Maths
- Matlab/Simulink
- C/C++, Python
- Linux, RTOS
- Electronics
- RC

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Autonomous Systems for Civilian Applications
Development of an Unmanned Autonomous Motorized Trike Hang Glider

In this thesis, you will design and build a scaled model of a motorized trike hang glider. In order to acquire flight data for the system identification, you will initially fly the trike using a radio control (RC) system. The system identification of the trike will help you to develop the flight control algorithm for the platform.

In order to make your motorized trike an autonomous platform, you will develop a flight control algorithm in Matlab/Simulink. Using Matlab Coder, the developed flight control algorithm will be converted into C/C++ code to run on an autopilot module. The completed system will perform autonomous waypoint navigation and precision landing.

If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the flight controller system.

Required Skills:
- Maths
- Matlab/Simulink
- C/C++, Python
- Linux, RTOS
- Electronics
- RC
- Hands-on-mechanical building skills
A multirotor Unmanned Aerial Vehicle (UAV) is a type of vertical take-off and landing (VTOL) vehicle with independently controlled propellers. Its simplistic airframe design makes them attractive for the demonstration of various UAV control algorithms. Majority of multirotor UAVs can operate both indoor and outdoor. There is a significant body of knowledge about multirotor UAV airframe design and low-cost small flight controllers for autonomous flight on the Internet as well as numerous open projects to learn.

This project requires the student to design and build the mechanical structure of a multirotor UAV and then develop flight control algorithms on an existing flight control computer (i.e. autopilot). If you are looking for an interesting, technically challenging project with significant outdoor time, and if you want to acquire some Radio Control (RC) flight experience and learn basic flight control theory, then this project is for you.

If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the flight controller system.

Required Skills:
- Maths
- Matlab/Simulink
- C/C++, Python
- Linux, RTOS
- Electronics
- Hands-on-mechanical building skills
This thesis is about the development of a Vertical Take-Off and Landing (VTOL) Unmanned Aerial Vehicle (UAV) capable of landing on a moving platform. The system will use live video stream from the camera on board the UAV for visual servoing. In this project, the student will build a UAV platform and develop the flight control algorithms in Matlab/Simulink. Using Matlab Coder, the developed flight control algorithm will be converted into C/C++ code to run on a given autopilot hardware. The complete system will perform autonomous waypoint navigation, take-off and from and precision landing to a moving platform.

If you are looking for an interesting, technically challenging project with significant outdoor time, and if you want to acquire some Radio Control (RC) flight experience, learn basic flight control theory and visual servoing then this project is for you.

If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the flight controller system.

**Required Skills:**
- Maths
- Matlab/Simulink
- C/C++, Python
- OpenCV
- Linux, RTOS
- Electronics
Development of a Tethered UAV for Prolonged Flight Operations

For the majority of battery powered Unmanned Aerial Vehicles (UAVs), the flight endurance is limited by the energy stored on board the platform. They have to land when battery level drops to a predefined low level. On the other hand, a tethered UAV is connected to a fixed or a mobile unit on the ground. The ground unit continuously supplies power to UAV to maintain a persistent flight. The same tether can also provide a high-bandwidth communication path between UAV and the ground unit. This is particularly useful for tasks such as prolonged aerial monitoring and surveillance, airborne communication relay.

The aim of this challenging thesis is to design and develop a tethered UAV system. After extensive indoor tests, the system will be operated in the field as a high-definition video feed and communication relay.

If you are looking for an interesting, technically challenging project with significant outdoor time, and if you want to acquire some UAV flight experience and learn basic flight control theory then this project is for you.

If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the flight controller system.

Required Skills:

- Math
- Matlab/Simulink
- C/C++, Python
- Linux, RTOS
- CAD
- Electronics
A returning boomerang is a spinning aerial device that displays interesting flight behaviour once it is launched. Despite its simple physical construction and shape, its flight characteristic is complex.

In this thesis project, you will build an instrumented boomerang and launch it using our robotic boomerang launcher apparatus. During its short flight, the instrumented boomerang will collect flight data. You will use this data for flight characterisation of the boomerang.

This is a unique project requires extensive electronics, programming and math skills. If you are passionate about the physics of spinning bodies, then this project is for you.

**Required Skills:**
- Maths
- Physics
- Matlab/Simulink
- C/C++, Python
- Electronics
Manual video recording of a fast-moving UAV from the ground is a challenging task even if the camera is mounted on a fluid head tripod. Tracking the UAV to keep it at a desired point in the video frame is particularly difficult when a high zoom lens is used. Furthermore pointing the camera to UAV when the UAV flies straight over the camera (i.e. 90-degree elevation angle) may not be possible even when using a high-end fluid-head tripods.

This project is about designing, building and testing of a high-speed tracking system to be mounted on a tripod. The tracking system will be capable of carrying a DLSR (or similar) video camera with a zoom lens. The system will receive the GPS data from the UAV and be able to control the pan-tilt angle to keep the UAV in a desired spot in the video frame.

**Required Skills:**

- Maths
- Matlab/Simulink
- C/C++, Python
- Electronics
- Hands-on-mechanical building skills
Tile Bonding Analysis Using Impact Acoustics

Impact acoustic is a versatile Non-Destructive Testing & Evaluation (NDT&E) technique. It is based on the characterisation of time-frequency features of the acoustic signals obtained from the impact on the surface being tested. Impact acoustic is used in many different areas; such as medical examination, classification of kernels, detection of metal fatigue etc. In this thesis, impact acoustic will be used for the analysis of tile-wall/floor bonding strength.

You will design, build and test a compact, hand-held NDT&E tool capable performing impact acoustic analysis on tiles. This is a challenging project and requires strong maths, programming and mechatronic design skills. If you are interested in machine learning, this project also offers an optional opportunity to incorporate machine learning techniques into the signal classification system.

Required Skills:
- Maths
- Matlab/Simulink
- C/C++, Python
- Electronics
- CAD
- Hands-on mechanical skills
Civil engineering applications of robots are rapidly increasing. This thesis topic is about designing and building a wall-climbing robot that can be used on different types of walls. There are many different techniques for wall climbing, abseiling, vacuum adhesion, electroadhesion etc.

Your robot will be equipped with a Non-Destructive Testing & Evaluation (NDT&E) sensor to detect faults in the wall. The robot will be teleoperated by an operator using a tablet. This is a challenging project and requires strong maths, programming and mechatronic design skills.

**Required Skills:**
- Maths
- Matlab/Simulink
- C/C++, Python
- Electronics
- CAD
- Hands-on mechanical skills
Robots and other autonomous mobile platforms can be used in many environmental monitoring applications. These platforms need to be able to operate in real, unstructured environment. Performing data-gathering missions in real, outdoor environment bring its own challenges.

This thesis topic is for you; if you feel that, you want to do something positive about the environment. This thesis project will focus on the development and operation of an autonomous boat on lakes and irrigation channels. You will design and build the boat and develop guidance, navigation and control codes for it.

Required Skills:

- Maths
- Matlab/Simulink
- C/C++, Python
- Electronics
- CAD
Self-driving Autonomous Guided Vehicles (AGV) is becoming increasingly popular in material handling in a warehouse and in modern industrial environments. They use a variety of navigation and guidance techniques including magnetic tapes, inductive guidance wires, laser scanners, omnidirectional cameras etc.

This thesis is about designing, building and testing a scaled model of an autonomous forklift. The autonomous forklift will be able to localise itself in a mock-up warehouse and transport pallet loads while avoiding obstacles.

This is a challenging mechatronics project and requires strong maths, programming and mechatronic design skills.

**Required Skills:**
- Maths
- Matlab/Simulink
- C/C++, Python
- Electronics
- CAD
- Hands-on mechanical skills
In a nutshell, a telepresence robot is a mobile platform with the bidirectional audio-visual interface and it is operated from a remote location. In a typical operational scenario, the user connects to a telepresence robot and teleoperates it to move in its environment while getting live feedback from the robot. Communication bandwidth, packet loss rate, latency, type of human-machine-interface (HMI) presented to the user, mechanical properties of the robot and many other factors affect the telepresence experience, hence the user satisfaction.

This thesis is about designing and building a telepresence robot with different levels of autonomy, including obstacle avoidance, assisted autonomy by providing to “go to destination”, “follow a person” types of functions. This project requires strong, hands-on mechanical, electronics and software design and development skills and experience. Furthermore, experience in web-technologies, such as PHP, HTML5, CSS3, JQuery, C/C++, Python on embedded Linux platforms are essential.

**Required Skills:**

- Maths
- Matlab/Simulink
- Electronics
- Linux
- PHP, HTML5, CSS3, JQuery, C/C++, Python
- (IOS + Swift) and/or (Android + Java)
- CAD
Ever increasing popularity of mobile devices has created an unprecedented market for innovative mobile apps. Although the overwhelming majority of mobile apps are using only the hardware of the mobile device and some web services, there is an increasing interest in directly linking mobile devices with external physical platforms. AR-Drone mobile app is an example in which an external physical platform (an AR-Drone multicopter) is controlled by a mobile device (such as iPhone or iPad, etc.).

This thesis will focus on the mobile app development for robotic platforms in which the student will design, develop and demonstrate a teleoperated robotic platform using a mobile device. This project requires strong, hands-on electronics and software design and development skills and experience. Furthermore, experience in IOS and/or Android along with their app development environments as well as experience in web-technologies (PHP, HTML5, CSS3, JQuery on embedded Linux platforms) are essential.

**Required Skills:**

- Maths
- Electronics
- (IOS + Swift) and/or (Android + Java)
- Linux
- PHP, HTML5, CSS3, JQuery
- C/C++, Python
Mechatronics

Path Planning and Control of a Microrobot Team

Microrobotics is a rapidly developing field deals with robots smaller than 1mm. Applications of microrobotics range from in-vivo medical operations to micro-fabrication, to micro-scale particle manipulation. Recently we have developed an experimental setup in which multiple microrobots have been operated on a 2D test arena using a combination of magnetic field and mechanical surface waves. The size of these microrobots varies between 200-2000 microns.

This thesis will focus on the development of a path planning and control system for a team of microrobots on a 2D test arena. This project requires knowledge and interest in physics, particularly in the fields of electricity and magnetism, oscillations and waves. Furthermore, hands-on experience in electronics circuit design, programming in Simulink, C/C++ and Python are essential.

Required Skills:

- Physics
- Maths
- Matlab/Simulink
- Electronics
- Linux
- OpenCV
- C/C++, Python
Microrobotics is a rapidly developing field deals with robots smaller than 1mm. Applications of microrobotics range from in-vivo medical operations to micro-fabrication, to micro-scale particle manipulation. Recently we have developed an experimental setup in which multiple microrobots have been operated on a 2D test arena using a combination of magnetic field and mechanical surface waves. Size of these microrobots varies between 200-2000 microns.

This thesis will focus on the development of a vision-based closed loop control system for the microrobots. This project requires knowledge and interest in physics, particularly in the fields of electricity and magnetism, oscillations and waves. Furthermore, hands-on experience in electronics circuit design, programming in Simulink, C/C++ and Python are essential. As the microrobots move very fast on the 2D test arena, the vision system has to be fast to track the microrobots. Therefore hands-on experience on OpenCV would be helpful.

**Required Skills:**
- Physics
- Maths
- Matlab/Simulink
- Electronics
- Linux
- OpenCV
- C/C++, Python
Microrobotics is a rapidly developing field deals with robots smaller than 1mm. Applications of microrobotics range from in-vivo medical operations to micro-fabrication, to micro-scale particle manipulation. There are various methods to move the microrobots in the test environment, including thermal, optical, chemical, electrostatic, electromagnetic, bacteria propelled systems.

This thesis will focus on the development and testing of an experimental setup in which microrobots will be moved in 3D space using accurately controlled magnetic field vectors generated by multiple electromagnets. This project requires knowledge and interest in physics, particularly in the fields of electricity and magnetism, oscillations and waves. Furthermore, hands-on experience in electronics circuit design, programming in Simulink, C/C++ and Python are essential.

**Required Skills:**
- Physics
- Maths
- Matlab/Simulink
- Electronics
- Linux
- OpenCV
- C/C++, Python
The Australian Centre for Field Robotics' marine systems group undertakes fundamental and applied research in a variety of areas related to the development and deployment of autonomous marine systems. We have a number of thesis projects available that will support studies in the fields of engineering science, ecology, biology, geoscience, archaeology and industrial applications. More details of our research can be found at http://marine.acfr.usyd.edu.au.

Title: **ROV Guidance, Navigation and Control for Antarctic Benthic Survey**  
Supervisors: Stefan B. Williams and Oscar Pizarro

We have recently submitted a proposal to conduct surveys of benthic (i.e. seafloor) surveys under ice in Antarctica using a small Remotely Operated Vehicle (ROV). This will complement our surveys of benthic sites around Australia that aim to assess the impacts of changing climate on benthic habitats. We are looking for students to assist with the design of navigation, guidance and control systems for this system. In particular, thesis topics will include the design of acoustic positioning systems suitable for use under ice, altitude control systems for maintaining an imaging payload at a fixed height above the seafloor during the surveys and the design of imaging platform and data processing tools required to generate detailed 3D maps of the seafloor. Students will be expected to research current trends in underwater navigation, guidance and control and to validate these in trials in preparation for deployments in Antarctica.

Title: **RobotX Unmanned Surface Vessel competition**  
Supervisors: Stefan B. Williams and Oscar Pizarro

In 2012, The U.S. Office of the Naval Research (ONR) launched the biennial Maritime RobotX Challenge (RobotX). Through this competition, ONR aspired to engage regional partners around the Pacific Rim while creating a new, high-level competition focused on autonomous surface vehicle platforms and sensors. The first RobotX Competition was held in October 2014 in Singapore and this was followed by a competition in Hawaii in December 2016. The University of Sydney has recently taken delivery of a WamV Unmanned Surface Vessel and plans to enter a team in the RobotX competition in Hawaii in 2018. We are looking for enthusiastic thesis students to undertake research related to this platform and to help lead the University of Sydney RobotX team.
Title: **Dynamics and Control of Autonomous Underwater Vehicles**
Supervisors: Stefan B. Williams, Oscar Pizarro, and Mitch Bryson

We have a pair of Autonomous Underwater Vehicles (AUV) that are used for surveying the seafloor in depths well beyond those that can be reached by a diver. We are looking for one or two motivated students to undertake a study of the dynamical properties and control design of these vehicles. These studies will result in improvements to the real time control of the vehicle, including its ability to hold depth and follow tracklines in energetic environments. Based on the outcomes of previous student theses in the area, there is also scope for completing the design of optimised propellers, fabricating them and demonstrating enhanced endurance. Students will be expected to research current trends in long-term AUV design, propose design modifications to our existing vehicles and validate their designs in simulation and during engineering trials held periodically throughout the year.

Title: **Image classification in reef environments**
Supervisors: Stefan B. Williams, Oscar Pizarro

This project will explore the classification of seafloor type based on visual and sonar information collected by an Autonomous Underwater Vehicles. The volume of data being collected by these systems precludes detailed manual analysis of the data. Machine learning algorithms have recently been shown to be effective at identifying patterns within this data that can help to guide further analysis. We are also interested in developing methods capable of recognizing particular organisms within the highly unstructured marine environments we work in. Students interested in this project should have strong software skills. One or two students will be accepted for this project.
Unmanned Surface Vessels (USV) are increasingly being used for tasks such as seafloor mapping using acoustic sensing. We have recently begun a project to look at the design and implementation of such vehicles. Projects will focus on aspects of navigation, control and sensing for USV systems. One of the key aspects of such survey work is the ability to modify plans while the vehicle is underway and to respond to disturbances such as wind, waves or strong currents. This work represents a crucial step in the development of autonomous technologies capable of long-term, reliable deployment. Students interested in this project should have strong software skills and some experience with electronics and hardware design. Tasks will include interfacing to the existing vehicle path planner as well as exploring novel methods of responding to sensed data. One or two students will be accepted for this project.
Title: **Real-time, Multi-Vehicle Visual Simultaneous Localisation and Mapping (SLAM)**
Supervisors: Stefan B. Williams, Oscar Pizarro, Lachlan Toohey and Mitch Bryson

We operate an imaging autonomous underwater vehicle (AUV) that takes stereo photographs of the seafloor. Currently these data are used in post-processing to refine the vehicle's navigation using algorithms from recent robotics research collectively known as simultaneous localisation and mapping (SLAM). By enforcing loop closures where images are seen to contain the same features, such visually-augmented navigation can dramatically improve our ability to geo-reference the location of the vehicle and the data it has collected. Research in our group has led to efficient implementations of SLAM that are suitable for real time operation; however, the image processing required to generate the visual features used for identifying loop closures is too computationally intensive to run in real time on our existing hardware. We seek a motivated student with strong programming skills and an interest in SLAM to research hardware/software options for real-time feature extraction and to implement a system suitable for real time use on multi-AUV systems.

Title: **Unmanned Aerial Shark Patrol**
Supervisors: Stefan B. Williams and Mitch Bryson

There is a growing interest in the use of Unmanned Aerial Vehicles (UAVs) in a variety of domains. One area of potential growth is in the patrol of beaches, with a particular focus on aerial visual identification of sharks. However, this can be hindered by surface reflection and attenuation through the water column. Attenuation reduces contrast, limiting the depth to which objects can be effectively imaged through water. Specular reflection of sunlight at the water's surface exacerbates the situation by adding interference, often bearing more energy than the signal of interest. As a result, both human and automated visual systems become overwhelmed by the stronger interfering signal. We have recently completed a study demonstrating that specifically tailored multispectral cameras are suitable for enhancing through water visibility for aerial shark detection. This project will seek to develop a compact multispectral camera system for aerial flight. One to two student projects will be available to build a prototype imaging system and demonstrate algorithmic methods for contrast enhancement. Research will also investigate recent developments in liquid lens techniques that allow for improved aerial surveillance of underwater environments.
We are developing underwater computational imaging systems and employing them for a number of demanding underwater applications. Underwater imaging is difficult because colour-selective attenuation introduced by the water column limits imaging range, suspended particulate matter interferes with scene content, and refraction at the underwater viewport results in non-projective imaging geometry and causes colour-dependent distortion. That underwater imaging platforms are typically mobile exacerbates these problems by limiting exposure time, and backscatter caused by murky water limits the effectiveness of increased illumination by overpowering the signal of interest. We have been investigating the use of Lightfield Cameras comprised of a small lenselet array in front of an imaging sensor for generating 3D models of an underwater scene. We are also looking at the possibility of using an array of transparent spheres for providing wide field of view and depth information. We are seeking one of two students to be involved in helping with the design and validation of next generation underwater imaging systems. The project will involve basic optical modelling, design and fabrication of camera systems, tank tests through viewport and the development of calibration procedures. Deployment in real underwater scenes from a dock or AUV system will serve to validate the resulting design.

Elements of an underwater computational imaging model: Potentially dynamic ambient and artificial illumination propagates through the water column (A), experiencing forward- and backscatter, occluding particulate matter and wavelength-dependent attenuation. The camera’s optical model includes the air/viewport/water interface (B) and an optical system (C). The image sensor (D) employs a detailed pixel and noise model, and the noise amplification characteristics of the decoding process (E) are included.