Projects Semester 1 2014

BEB 801/2 projects

We have a great range of projects in mechatronics, robotics and computer vision. Please directly contact the supervisors associated with the projects.

- BEB 801/2 projects
- Peter Corke's Projects.
- Michael Milford's Undergraduate Projects.
- Ben Upcroft's Projects
- Michael Warren's Projects
- Chris Lehnert's Projects
- Feras Dayoub's Projects
- Chris McCool's Projects.
- David Ball's Projects (I am full for 2014!)
- Jason Ford's Projects (new projects 2015)
- Frederic Maire's Projects
- Ruth Schulz's Projects
- Matthew Dunbabin's Projects
- Thierry Peynot's Projects

Peter Corke's Projects.

About Peter. If you email me please be sure to put "BEB801 project" in the subject line, that way I'll notice it.

1: An armed robot

Description

Our Guiabot has no arms, and this prevents it from opening doors, pressing lift buttons, and picking things up. The aim of this project is to mechanically fit a Kinova Mico arm (google it) to the robot and develop the software to provide arm opening and button pushing functions. Opening a door is quite a challenge; the robot needs to be initially in a good position, within reach of the handle. Grasp it, then move it which is complex because the motion is constrained by the handle mechanism, then pull or push the door and move the whole robot while still holding the door. Compliant motion and force control will be critical.

Skills

Mechanical design and construction, C++/Python programming in a Linux/ROS environment.

No. of Students

1 to 2
2: Measuring water with vision

| Description | This is a research oriented project that will develop computer vision algorithms to detect the quantity and quality of water flowing in a waterway. Typically this involves installing water wheels or pressure sensors into the stream, which is expensive to install, requires ongoing maintenance and can be damaged by flood events. Consider the picture above. Could we measure the width and arc of the flow using a camera and computer vision algorithms? If we can do that, can we relate that to flow in litres /min? Can we determine whether the water is clear or turbid? Could we build this into an app that ran on a smart phone? |
| Skills | computer vision, research, software (Linux, C, C++, Python) |
| No. of Students | 1 |

3: Telerobotics for surgical proctoring

| Description | This is a practical client-oriented project. In a state with a low population density like Queensland it is challenging to provide high-quality healthcare everywhere. The aim of this project is to develop a simple and low-cost telerobotic system that allows a city-based specialist to assist/proctor a remote doctor. This will allow the city-doctor to see the remote patient and to "point" (via robotic laser pointer, data projector etc) to parts of the patient so as to assist the remote doctor. This project involves working with a neurosurgical registrar at the Townsville Hospital to fully understand the requirements, develop a scope document, create a prototype and ideally to trial it. |
| Skills | Software (C, C++), networking, Skype API, mechatronic design, creative thinking |
| No. of Students | 1 |

4: Mechatronics meets electronic art
There is an opportunity for up to five students with mechatronic or software skills to work on an interactive electronic artwork for Europe's largest light-show at the 2014 Ars Electronica Festival with an audience of approximately 100,000 people. Engineering students will work in collaborative teams with honours-level students from Creative Industries Faculty from the areas of Interactive and Visual Design, Dance, Music and Visual Arts. (Ars Electronica ran the nighttime quadrotor display during last year's Robotronica event at QUT)

Teams will develop a proof of concept prototype for their project in first semester. At the end of first semester, projects will be selected for showing at the 2014 Ars Electronica Festival in Linz, Austria based on how good the concept is and whether they are technically feasible. If your project is selected, you will work on refining it during second semester and then travel to Austria in September to present it at the festival.

If you're a bit interested already, there's a briefing session you can attend:

**Date:** 25th Feb 2014  
**Time:** 2pm  
**Location:** GP- P502  
**RSVP by 24th Feb:** lubi.thomas@qut.edu.au

The artwork will make use of a number of open-hardware FM radio frequency responsive micro-controller modules which are controllable over a city-scale. You will play a key role in contributing to the development of the concept by suggesting innovative uses of technology and by translating the artistic concepts into robust, working electronic/mechatronic devices. There will be a workshop with the developers of the FM modules to introduce you to the platform and how to program/interface with it and regular futurelab cademy seminars to keep you on track. We will have approximately 400 of these modules, so you can think BIG!

The trip:

- Dates: 1 September – 14 September (dates may vary – but it will be around this time).  
- Cost: Short-term student mobility funding will cover some of the cost – but there will likely be some cost to the students too.

The festival:

- Ars Electronica is the premiere international electronic arts festival [http://www.aec.at/festival/en/](http://www.aec.at/festival/en/)

The technology platform:


More info:


**Skills**

- electronics, software, mechatronics, creative thinking

**No. of Students**

- Upto 5
high level and brief - feel free to contact me to discuss in more detail. The projects vary from applied to theoretical.

About Michael.

Superfast GPU-based Visual Navigation Algorithms

Modern GPUs offer amazing parallel computing capability. This project concerns implementing some relatively straightforward state of the art visual navigation algorithms on a high end GPU. Doing so will enable us to do cool things like making a camera-based GPS system that scans millions or even billions of images in a second and tells you where in the entire world you are located.

| Description | • Using C/C++ and CUDA / OpenCL
  • Implement algorithms on a GPU |
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<tr>
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</thead>
<tbody>
<tr>
<td>Skills</td>
<td>C or C++ programming, GPU-based programming desirable</td>
</tr>
<tr>
<td>No. of Students</td>
<td>1</td>
</tr>
</tbody>
</table>

Phone-based Visual GPS

Modern smart phones have incredible computing power. This project concerns porting some relatively straightforward visual navigation algorithms onto a phone to create a publicly appealing navigation app which uses images from the camera's phone to tell the user where they are in the world, day or night, indoors or outdoors, in the car and on the footpath.

| Description | • Using C/C++ and Java / NDK
  • Implement algorithms on a smartphone efficiently to enable real-time operation
  • Design a software-hardware system to provide live navigation instructions to a human wandering around QUT and the Botanic Gardens.
  • Mock up a sexy tech demo |
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<tbody>
<tr>
<td>Skills</td>
<td>C or C++ programming, Java / NDK programming, hardware, software, C++, Matlab, human interaction design skills</td>
</tr>
<tr>
<td>No. of Students</td>
<td>1</td>
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</table>

Solving the Infinite Memory Holy Grail

Our unique biologically-inspired mapping and navigation algorithms offer the potential for implementing a memory system in software with effectively unlimited memory potential. This blue sky project will require a self-driven, open-minded, laterally thinking student to pursue possible avenues of investigation in attempting to solve this extremely challenging problem.

<table>
<thead>
<tr>
<th>Description</th>
<th>• Using C/C++ and Matlab</th>
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<tbody>
<tr>
<td>Skills</td>
<td>• Using C/C++ and Matlab</td>
</tr>
<tr>
<td>No. of Students</td>
<td>1</td>
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The Robot Wanderer
**Using ROS (Robot Operating System) develop movement behaviours for a new Pioneer robot and/or Robotnik robot so that it can randomly wander the hallways in a safe manner using its sensors (laser, Kinect, camera, sonar) to avoid hitting things. Log all sensor data in a usable format.**

**Skills**
- robot electrical and electronics hardware
- C or C++ programming
- experience using external software packages such as OpenCV, RoS.

**No. of Students**
1

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**Brain-based Algorithms for Navigation**

**Description**
- In Matlab and C++, develop and test computational models of some of the most recent theories of how animals use their brains to navigate.

**Skills**
- Neural networks
- strong math
- C or C++ programming
- experience using external software packages such as OpenCV and ROS.

**No. of Students**
1

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**Android Long Exposure Maximum Gain Continuous Photos Software**
Need a photo / video app that can:

- Take continuous photos of at least 2 MP with ISO ratings of 2500+ and (settable) exposure times of up to 2 seconds.

- So if I set it at an exposure duration of 500 ms, I would want it taking photos at least every 1 second, and hopefully closer to every 500 ms.

- It is perfectly acceptable that the resultant images are a) very noisy and b) very blurred if the camera moves during capture. Appropriate image exposure is the priority, image quality comes a distant second. Output images can be grayscale.

- Capture must be able to be continued for at least an hour (given enough memory).
  
  - Would prefer not to have to root the phone.
  - Using stock apps I can already grab 1 second interval photos at ISO1600 and exposure 500 ms, so needs to be significantly better than that.
  - Apps that scrape the screen over time are not acceptable.
  - Post processing software pixel binning is not acceptable (I can already do that, and that's how I generated the attached photo).

I have attached an example of the sort of image that is acceptable (the one on the right). Ideally I'd want it much better exposed than the example one.

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Ben Upcroft's Projects

About Ben

3D mapping with a mobile phone

<table>
<thead>
<tr>
<th>Description</th>
<th>The aim of this project would be to implement an online mapping algorithm for 3D reconstructions in computer vision on a mobile phone. The scope of the project would be to initially fuse the inertial measurement unit (IMU) and camera information from a mobile phone to track and simultaneously map the world in real-time. This has recently been demonstrated in international conferences, and the next step would be to build 3D reconstructions using only the phone.</th>
</tr>
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<tbody>
<tr>
<td>Skills</td>
<td>C or C++ programming</td>
</tr>
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</table>
High quality images from a simple webcam for UAVs

**Project 1:** Recently, it has been shown that very high quality images can be obtained from poor lenses. For example, see High quality computational imaging through simple lenses at the University of British Columbia.

This project would involve reimplementing this work and attempting to build a real-time system for correction on incoming video streams. These videos would come from robotics platforms such as an unmanned aerial vehicle (UAV) or submarine.

**Project 2:** This project will develop localisation techniques for high speed fixed wing UAVs travelling through urban canyons.

<table>
<thead>
<tr>
<th>Skills</th>
<th>C or C++ programming</th>
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<tr>
<td>No. of Students</td>
<td>1 to 2</td>
</tr>
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</table>
This project aims to localise a robot in a place it's never been using vision and information from the internet.

Skills
C++ programming

No. of Students
1 to 2

Agricultural automation in Third World countries

According to the Gates Foundation Agricultural Development initiative:
‘...population growth, rising incomes, dwindling natural resources, and a changing climate have caused food prices to rise and agricultural productivity has once again become strained. Many of those affected are smallholder farmers. Three-quarters of the world's poorest people get their food and income by farming small plots of land about the size of a football field. Most of them barely get by—struggling with unproductive soil, plant diseases, pests, and drought... Helping farming families increase production in a sustainable way, and sell more crops, is the most effective way to reduce hunger and poverty over the long term.’

The goal of this project is to use mobile phone technology to build effective visual detection and identification of diseases and weeds, and automatically suggest methods for defending against these problems. The idea is for it to be like an online doctor that looks at symptoms and suggests a ‘cure’.

Skills
C/C++ Programming

No. of Students
1 to 2

Removing blur from poor quality images

The goal of this project is to use known motion of a camera to remove blur from images similarly to http://helpx.adobe.com/photoshop/using/reduce-camera-shake-induced-blurring.html.

The goal of this project is to compute the pose of a moving camera even in poor lighting. This has large implications in robotics and mobile phone applications ranging from UAV navigation to removing camera shake from an image.
### Visual weed identification for agricultural applications

**Description**
This project will use state of the art computer vision algorithms to identify weeds in the presence of poor lighting and occlusions. The end goal of this project is to detect and destroy weeds using dedicated robotic platforms in broadacre agriculture. This is part of an exciting new $3M Agricultural Robotics Centre at QUT aimed at developing new lightweight farm platforms to address current and future agricultural challenges.

<table>
<thead>
<tr>
<th>Skills</th>
<th>C++ programming, Maths</th>
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<tbody>
<tr>
<td><strong>No. of Students</strong></td>
<td><strong>1</strong></td>
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### AgBot 2D and 3D Simulator

![AgBot 2D and 3D Simulator](image)

**Description**
- Develop 2D and 3D simulator with physics engine for an autonomous weed spraying robot

<table>
<thead>
<tr>
<th>Skills</th>
<th>C++ programming, computer graphics</th>
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<tr>
<td><strong>No. of Students</strong></td>
<td><strong>1</strong></td>
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</table>

### Crop identification for fruit and veg picking
This project will use state of the art computer vision algorithms to identify crops such as pineapples and bananas in the presence of poor lighting and occlusions. The end goal of this project is to detect and pick the crop using dedicated robotic platforms for horticultural applications. This is part of an exciting new $3M Agricultural Robotics Centre at QUT aimed at developing new lightweight farm platforms to address current and future agricultural challenges.

**Skills**

- C++ programming, computer graphics

**No. of Students**

- 1

### Agricultural Robotic Platform Design

This project will aid in the development of a new robotic platform that will form part of a robotic coordinated team to address agricultural challenges such as weed resistance and increasing crop yield. The end goal of this project is to aid in developing a modular platform for commercialisation purposes. This is part of an exciting new $3M Agricultural Robotics Centre at QUT aimed at developing new lightweight farm platforms to address current and future agricultural challenges.

**Skills**

- CAD, electrical/mechanical design

**No. of Students**

- 1

### Novel Methods for Destroying Weeds

The aim of this project is to investigate novel methods (mechanical, electrical, microwave, etc) for destroying weeds. The end goal of this project is to aid in developing technologies that address the increasingly detrimental problem of herbicide resistance in weeds. This is part of an exciting new $3M Agricultural Robotics Centre at QUT aimed at developing new lightweight farm platforms to address current and future agricultural challenges.

**Skills**

- CAD, electrical/mechanical design
Robotic Ethics and Legalities

<table>
<thead>
<tr>
<th>Description</th>
<th>The aim of this project is to investigate ethical and legal issues in deploying robotic platforms in the agricultural domain - how does this effect the work force?, the users?, and what are the safety requirements? The end goal of this project is to aid in developing policies for robotic use in agriculture and horticulture. This is part of an exciting new $3M Agricultural Robotics Centre at QUT aimed at developing new lightweight farm platforms to address current and future agricultural challenges.</th>
</tr>
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<tbody>
<tr>
<td>Skills</td>
<td>Ethics, robot interests, law</td>
</tr>
<tr>
<td>No. of Students</td>
<td>1</td>
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Michael Warren's Projects

About Michael

e-mail: michael.warren@qut.edu.au

Project descriptions are brief and negotiable. If anything captures your interest, get in touch!

There is potential for further work as a PhD or masters, as well as conference publications to give you an edge on your CV.

Image/Satellite UAV Localisation

| Description | Cheap GPS systems are not particularly accurate and don’t often work in urban and natural canyons. More accurate GPS systems are often heavier and more expensive.
Can we use an on-board camera to capture images of the ground environment and localise based on a satellite map? |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Skills      | • C++ programming
• Math                                                                                                                   |

-------------------------------------------------------------------------------------------------------
| No. of Students | 4 |

**Stereo VO for Underwater Mapping**

<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td>We are interested in capturing imagery of underwater environments for environmental science applications. Unfortunately, the calibration techniques we use are cumbersome and don't work very well underwater!</td>
</tr>
<tr>
<td>This project will involve developing techniques to generate accurate 3D models of underwater scenes using GoPros and other cheap cameras, and developing techniques to accurately calibrate cameras underwater by inexperienced divers.</td>
</tr>
<tr>
<td>You'll develop calibration code using existing Matlab software for alternative calibration patterns and demonstrate 3D reconstructions from images only using new calibration</td>
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<table>
<thead>
<tr>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>- Matlab/Python programming</td>
</tr>
<tr>
<td>- C++ programming</td>
</tr>
<tr>
<td>- Math</td>
</tr>
</tbody>
</table>

| No. of Students | 4 |

**Change Detection in Airborne 3D Reconstructions**
### We have a super-light UAV that automatically captures imagery for the generation of 3D surface models of the environment.

What we are really interested in is: can we detect change in crops, forests and run-off using this cheap and simple hardware?

You’ll gather imagery using the Swinglet CAM UAV, process and 3D render the data and develop algorithms to detect change in dense 3D models.

If you are interested in the environment, surveying, robotics and using very powerful data processing this project is for you!

**Skills**
- C++ or Matlab programming
- Computer Science
- R/C or other aerospace knowledge a bonus
- Maths

**No. of Students**
1

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### Blur Removal in Robotic Vision

Successful robotic vision for tracking and pose estimation is dependent on clear, crisp images that are well lit and textured. This means we have to use expensive cameras with high quality lenses.

This project will explore using low quality cameras for pose estimation of robots that rivals more expensive cameras.

Using techniques for removing motion blur and lens aberrations you will develop Matlab and C++ code and work with a variety of cameras and robotics.

The research could be very easily published in an Australian Robotics conference!

**Skills**
- C++ programming
- Math
- Knowledge of image processing, camera optics a bonus

**No. of Students**
1

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### Chris Lehnert's Projects

**About Chris**

email: c.lehnert@qut.edu.au

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### Design of a Novel Omnidirectional Spherical Wheel
We have developed a continuous isotropic spherical omnidirectional drive mechanism that is efficient in its mechanical simplicity and use of volume. Spherical omnidirectional mechanisms allow isotropic motion, although many are limited from achieving true isotropic motion by practical mechanical design considerations. A prototype platform was built using a combination of machining and 3D plastic printing and is illustrated in the images above. This project aims to develop the next prototype improving the performance and addressing some flaws in the design.
Design of a Manipulator for Robotic Horticulture

This project aims to design a robotic manipulator for autonomously harvesting crops, for the new agricultural robot being developed at QUT. The project will involve designing and testing ideas using simulation and real hardware. Testing could include a 6 DoF manipulator or a recently purchased dual arm Baxter Research Robot.

Skills (not all required)
- Electro-mechanical Design
- Math
- Dynamics
- Control Theory

No. of Students 1 or 2

µAV (mUAV) - Open Source Palm Sized Quadrotor Version 2
The aim of this project is to develop an open source micro unmanned aerial vehicle that is capable of autonomously navigating within an indoor environment, which also fits in the palm of your hand. The goal is to develop and test the next version of the platform. The scope of the project is flexible, such as focus could be on developing the flight control system or testing and designing an on board vision system.

Skills (not all required)

- Embedded Design
- Electrical Design
- C programming
- Math
- Control Theory

No. of Students

1 or 2

Feras Dayoub's Projects

email: feras.dayoub@qut.edu.au

Photo of the robot used in all the projects below ---
1- The Sympathetic Robot

**Project Description:**
Mobile robot companions should be able to recognize human facial expression and respond accordingly. This project will teach you about face detection algorithms and give you the chance to implement a machine learning algorithm for facial expression recognition. At the end of the project, the robot should detect faces using its cameras and then response by changing its facial expression to match the human. The photo above shows the robot with its smiley face, another expression this face can express is angry, sad, bored, confused...

Working on this project will give you the opportunity to interact with a real mobile robot and to learn how to interface with ROS (the robotics operating systems) which is used widely in the robotics community.

**Project Type:**
Individual or group.

**Eligibility:**
Students with strong programming skills (ideally in C++ or/and Python).
Students with background in computer vision are preferable.

**Deliverables**
A short report
A working system implemented on a mobile robot (the robot is provided).

**Inquiries:**
Please contact Dr. Feras Dayoub directly, ph: 3138 9972, email: Feras.dayoub@qut.edu.au

2- The smart librarian assistant robot

**Project Description:**
We are looking for a student who is comfortable in programming using C++/Python and wants to enable our mobile robot to interact with the students in the QUT library. The robot has a touch screen which can be used for interaction with the students. The project goal is to enable the robot to receive a book location inquiry from the user and then guide the user to the location of that book. The robot should also be able to greet the visitors of the library and offer to give them a tour showing where are the different book sections located inside the library.

Working on this project will give you the opportunity to interact with a real mobile robot and to learn how to use ROS (the robotics operating systems) which is used widely for programming robots.

**Project Type:**
Individual or group.

**Eligibility:**
Students with strong programming skills (ideally in C++ or/and Python).
Students with background in computer vision are preferable.

**Deliverables**
A short report
A working system implemented on a mobile robot (the robot is provided).

**Inquiries:**
Please contact Dr. Feras Dayoub directly, ph: 3138 9972, email: Feras.dayoub@qut.edu.au

Chris McCool's Projects.

About Chris. Email: chris <dot> mccool <at> nicta <dot> com <dot> au.

1. In-Situ Fish Tracking
The goal of this project is to implement several different computer vision techniques to track fish using footage from in-situ video cameras. This will be more of a research oriented project and students are expected to have excellent programming and mathematical skills.

**Skills**
- Programming (Python, C++, Matlab), Maths

**No. of Students**
1 or 2

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**David Ball's Projects (I am full for 2014!)**

About David and contact details.

**Skippy the robot kangaroo**

The goal of this project is to build a robot kangaroo which can energy efficiently traverse complex outdoor terrain. We have prototyped and recently published an innovative joint that will enable the hopping motion. The next step is to progressively build a complete hopping robot kangaroo. This project has a number of parts to it including development of control systems for hopping, mechanical and electrical design, embedded control, development of the test system, etc. Depending on the student's experience, the project could be involve designing the electromechanical, control or perception systems.

**Desirable skills**
- C/C++ programming, MATLAB programming, electrical CAD, mechanical CAD

**No. of Students**
1 - 4

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**Docking for an agricultural robot**
### Platform design for an agricultural robot

| Description | The goal of this project is to design a new robot platform for agricultural robots. QUT's current platform is a modified utility vehicle that we are using to develop navigation algorithms. This project will investigate a completely custom design, considering, for example:  
  - the number and location of the wheels  
  - the type of wheels  
  - the motors  
  - type of energy source.  
  These must be considered in the context of:  
  - vehicle dynamics  
  - traction  
  - disturbance of the soil  
  - energy efficiency. |
| Desirable skills | Understanding of dynamics and kinematics, electromechanical design, mechanical CAD |
| No. of Students | 1 - 2 |

### Usability for an agricultural robot

| Description | The goal of this project is to increase the usability of our farm robot, the AgBot. The AgBot is a car-sized autonomous robot designed to work on broadacre farms. Possible outcomes of this research project include:  
  - a method of the AgBot informing those around of what it is about to do, including which direction it is about to go in  
  - a web interface to allow the end user, in this case a farmer, to give the AgBot relevant instructions and observe what it intends to do in the future. |
| Desirable skills | Web programming, C++ programming, User interface design |
| No. of Students | 1 |

### Navigation on a smartphone
Run navigation algorithms on your smart phone. Specifically port Op enRatSLAM to a smart phone and use it to navigate inside QUT buildings. Use this to control a low cost robot platform.

Desirable skills
Android programming, C++ programming, Java, ROS, OpenCV

No. of Students
1

Comparison of Outdoor Sensors

There are a wide variety of lost cost outdoor sensors that are commercially available. The goal of this project is to mount a variety of different sensors (laser/vision/radar/etc) sensors to a bar, perform experiments to record the results and then analyse the data to compare their performance under different conditions.

Desirable skills
C++ programming, ROS, Mechanical CAD

No. of Students
1

Jason Ford's Projects (new projects 2015)

Jason teaches into the Electrical Engineering and Aerospace Avionics course programs.

All projects are for 1 person (maybe 2).

Contact Jason at j2.ford@qut.edu.au (or x82207). Subject line: “BEB801/2 projects”.

<table>
<thead>
<tr>
<th>Title</th>
<th>Description</th>
<th>Comments/more information</th>
</tr>
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</table>
**NEW** Motion-aware path planning for aerial vehicles

Navigation and control of vehicles in the real world is a challenging problem for a number of reasons, including: sensing the world, controlling the vehicle, obstacle avoidance, path planning to achieve a real goal. This project focuses on the last three aspects, and aim to achieve motion-aware path planning algorithms for aerial vehicles in which path planning is achieved with an awareness of the flight properties of a vehicle operating in an uncertain environment.

This project involves software development, investigation of planning algorithm options, and visualisation tools.

Background References:

**NEW** Automating Advanced vision-based collision for changing detection environments.

The use of aviation automation technology, including un-manned aircraft systems (UASs) is expected to rapidly increase over the next few years. However, under the limitations of current UAS technology, any increased use will lead to corresponding increase of collision risk, and hence led to increasing importance been placed on the development of reliable automated aircraft mid-air collision warning and avoidance technology, or sense-and-avoid technology (especially for small UAVs)[1]. Recently, spot dim target detection techniques coupled with tracking filters have been extensively investigated as vision based solutions for the detection part of this problem (in particular, for detection from sky-regions rather than detection from ground clutter) [2]. Unfortunately, achieving reliable operation in a range of lighting conditions, and against a range of backgrounds remains difficult and these limitations motivate the investigation of new detection techniques.

This project proposes to extend current state-of-art for vision based mid-air collision detection approaches in two ways by investigating extension of the current state-of-the-art "sky-region" aircraft detection technology [2] to automate detection in changing lighting conditions.

Background references:


**NEW** Robust change detection in dynamics

Safe and efficient operation in a dynamic uncertain real-world environment requires access to a range of sophisticated detection and decision making capabilities. In fact, many decades of statistical decision and control system theory effort has been motivated by the desire to automate decision making well beyond human sensing and cognitive limits. Yet some aspects of the real-world continue to evade appropriate and useful representation, particularly in a range of situations requiring good decisions that are made with an appreciation of the uncertainty being faced. Change detection is a signal processing problem in which the decision objective is to detect a substantial behavioural change in a monitored dynamic system.

This project will investigate sophisticated decision and estimation tools to help achieve better real world automation in rapidly changing environments. It will involve simulating and evaluating new mathematical tools and concepts.
<table>
<thead>
<tr>
<th><strong>NEW</strong> Memory efficient Compressed sensing vision</th>
<th>One of the main hurdles to use of compressed sensing ideas in image processing relates to memory and computational requirements. In this project, we will investigate the use of (Scrambled) Block Hadamard compression matrices rather than Gaussian compression matrices.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed sensing and image quality estimation</td>
<td>Over the last few years, sparse signal ideas have emerged that allow recovery of signals below sub-Shannon Limits (i.e. in situations that seem to violate well-respected signal processing performance limits). These sparse signal recovery ideas have lead to compressed sensing ideas (such as the single pixel camera, see link to the left). In this project, these new ideas will be used to develop new computational algorithms to quickly generate estimates the amount of information present in a provided image. Understanding the &quot;information content&quot; of an image helps build new technology.</td>
</tr>
</tbody>
</table>

### Frederic Maire's Projects

**2018 Student project topics proposed by Frederic Maire**

#### Human Cues for Robot Navigation

**Project Summary:** The world has many navigational cues for the benefit of humans: sign posts, maps and the wealth of information on the internet. Yet, to date, robotic navigation has made little use of this abundant symbolic information as a resource. This project will develop a robot navigation system that can navigate using information beyond the robot's range sensors by incorporating knowledge gained by reading room labels, following human route directions or interpreting maps found on the web. We will demonstrate the robot's navigation ability by comparing its performance with a human as it learns to find its way around campus by asking for directions, reading signs and maps, and searching the internet for clues.

**Description:** TBD, get in touch with me if you are interested in the overall project

**Skills:** C/C++ programming, Matlab, ROS

**Number of students:** 1-3
Environmental Acoustic Sampling for Stealthy Robots

Environmental sounds (acoustics) have been identified as a potential means to measure biodiversity and monitor wildlife behaviour. However, covering large areas or tracking moving wildlife is difficult and time consuming - a perfect task for autonomous systems. This project will conduct both field and laboratory work to assess different microphone configurations in their capacity to measure and localise environmental sounds as well as their ability to be incorporated onto a moving robotic platform for stealthy tracking of animals.

Skills
- Strong Math / Signal processing
- Matlab
- Research
- Embedded programming

No. of Students
1

Robotic Sailing for Persistent Monitoring of Oceans
Ocean processes, such as algal blooms or turbidity plumes, are dynamic and cover vast spatial scales. Monitoring these processes is primarily conducted using remote sensing satellites; however, this is costly and is only available during clear (cloud-free daylight) conditions and when a satellite is available. Novel underwater and surface robotic platforms are becoming available to persistently monitor these phenomena but they are costly and logistically difficult to deploy. This project will investigate the utility of conducting persistent ocean monitoring using small robotic sailing vehicles (modified RC sailing boats) by developing and experimentally evaluating path-planning and control algorithms taking into account forecasted and on-board weather measurements under a range of sea-states.

### Skills
- Math
- Sensors (GPS, weather, inertial)
- Embedded electronics and programming
- Matlab
- Research

### No. of Students
1–2

**Greenhouse Gas Sampling using Robotic Boats**
Environmental science is often limited by the ability to collect data at large spatial scales. The goal of this project is to assist researchers studying Greenhouse Gas emissions from inland waterways using robotic technology. Specifically this project will develop and implement real-time path planning algorithms to simultaneously coordinate six robotic boats recently developed at QUT which are capable of collecting greenhouse gas measurements from across entire water storages. This will involve consideration of both the usual robot problems of operating in natural environments, as well the sampling requirements for environmental scientists.

**Skills**

- Math
- Matlab
- C/C++ and/or Python programming
- Research

**No. of Students**

1

### Image-based Boat Detection in Marinas

**Description**

Just as today's robotic cars need to assess traffic conditions and detect obstacles so will future generations of robotic boats particularly as they manoeuvre in and out of populated marinas and harbours. This project will involve the development and evaluation of computer vision algorithms to detect and track the trajectory of moving objects (e.g. small boats) within a cluttered marina using monocular vision.
### Slingshot Robot

**Description**
This project involves the concept design and construction of a small (baseball size) robot that can survive being thrown or launched from a slingshot over large distances and relay live images to a base station.

**Skills**
- Mechatronics (design and construction)
- Physics
- Embedded programming

**No. of Students**
1

### Hyperspectral Image Classification of Vegetation

**Description**
QUT has recently acquired a small hyperspectral camera suitable for mounting on terrestrial and airborne robotic vehicles. This camera has the potential to allow classification of vegetation and terrain to assist with path-planning as well as species identification for smart agriculture and forestry. This project involves the algorithm development and software for processing the images from the hyperspectral camera to allow autonomous classification of the scene for future use on robotic platforms.

**Skills**
- Computer Vision
- Research
- Matlab
- C/C++ programming

**No. of Students**
1

### Interacting with Robots to Conduct Large-scale Environmental Research
Robotic platforms are revolutionizing the way in which the environment is monitored. Whist capable of collecting large and unique data-sets which scientists and managers can use to assess the state of the environment, they still require a relatively skilled engineer to successfully operate in natural environments. This limits the overall scientific and managerial efficiency potential. To realise a greater adoption of environmental robots by the wider community, the ease of operation and interoperation requires a simplification. Current interfaces lack intuitive functions for planning and control, and are unable to scale with increasing number of robots as well as to visualise current and historic data streams. Using a variety of techniques the group will engineer a complete information flow process based around a generic mobile device interface to allow seamless and simultaneous planning and control of multiple robotic assets with the ability to retrieve and view instantaneous and historically collected data.

Skills

- Android programming
- C++ programming, Java, ROS
- Research

No. of Students 1-2

**Stereo Vision Obstacle Avoidance for the Starbug Autonomous Underwater Vehicle**

This project involves the upgrade of the on-board real-time stereo vision obstacle avoidance software for the Starbug Autonomous Underwater Vehicle (AUV) using OpenCV. Upcoming missions in the Great Barrier Reef will require the AUV to navigate within complex environments at low altitude where there is a risk of entanglement with the seafloor. Therefore, a robust obstacle avoidance system is required. The Starbug AUV has two stereo camera pairs with the forward pair used for obstacle avoidance. With a recent upgrade of the AUV with a new on-board computer, the image processing algorithms can now exploit the latest OpenCV libraries. Specifically the student will interface with and calibrate the forward stereo cameras and upgrade the current obstacle avoidance strategy from the original custom code base to one using OpenCV. Finally, the student will experimentally evaluate the upgraded system against the original system in the field.

Skills

- Computer vision
- C++ programming, OpenCV
- Linux

No. of Students 1
Thierry Peynot's Projects

About Thierry
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Resilient Fusion of Multi-Sensing-Modality Data for Robot Perception

| Description | To conduct long-term missions, field-and-service robots must be able to operate safely and reliably in challenging environments and operational conditions, such as in the presence of fog, smoke, airborne dust, and rain. The use of multiple sensing modalities, such as laser, radar, visual cameras and infrared cameras, has been widely recommended in the literature to achieve resilient perception in such conditions. Distinct sensing modalities use physical processes to sense the environment that can react differently to different materials or environmental conditions, contrary to what is commonly assumed in the literature. For example, in dusty environments radars see through dust clouds while lasers will detect airborne dust particles. Conversely, glass windows in indoor environments are likely to be detected by a radar but missed by a laser. This can lead to failures of traditional Bayesian data fusion methods (i.e. catastrophic fusion). The aim of this project is to develop and validate algorithms for the fusion of data acquired by distinct sensor technologies so robot navigation becomes resilient to such conflicting sensor data. A related project concerns the use and adaptation of diagnosis techniques to realistic outdoor robotics. |
| Skills | • Computer Vision and/or knowledge of range sensors (such as laser range finders and/or radars)  
• Matlab or C/C++ programming |
| No. of Students | 1 or 2 |

Towards an Autonomous Astrobiologist Rover

(Automatic Stromatolite Recognition)
Astrobiologists look for signs of life on other planets, such as Mars. In particular, they hope to find stromatolites, i.e. rock structures that were formed by a biogenic process. The end goal of this project is to give a planetary rover the ability to help astrobiologists with this mission, by autonomously detecting stromatolites using computer vision. In this component of the project, the student(s) will investigate, develop and test algorithms that can detect and recognise characteristics associated with biogenicity (can you do it on the picture above?).

This project is in collaboration with the Astrobiology Centre at UNSW.

Skills
- Computer Vision
- Solid Matlab or C/C++ programming
- Knowledge of the Image Processing Toolbox (Matlab) or OpenCV

No. of Students 1 or 2

Reliable Terrain Traversability Estimation in Vegetated Environments

Operating safely and efficiently in vegetated environments is a major challenge for autonomous mobile robots. Vegetation may appear like a dangerous obstacle geometrically, although a robot may be able to drive through it safely. On the other hand, it may be relatively easy to classify vegetation using vision, but there may be a stone hidden behind it that constitutes a real obstacle for the robot. This project concerns the development of novel methods for terrain traversability estimation that are reliable in vegetated environments, using a combination of camera/laser and radar data.

Skills
- Computer Vision and/or knowledge of range sensors (such as laser range finders and/or radars)
- Matlab or C/C++ programming

No. of Students 1

Detection and Localisation of Negative Obstacles
Obstacle detection is a fundamental requirement for any autonomous mobile robot. Existing systems are quite good at detecting "positive" obstacles, i.e. elements above the ground that the robot should avoid. However, reliably detecting and recognising "negative obstacles", such as gaps or holes in the ground, remains challenging.

The goal of this project is to investigate methods to detect negative obstacles and try to determine the danger they represent for a particular vehicle. The student may use cameras or any other sensor appropriate for the matter at hand. Data sets will be available, although the student will be encouraged to acquire new data during the project.

**Skills**
- Computer Vision or knowledge of range sensors (such as laser range finders)
- 3D
- Matlab or C/C++ programming

**No. of Students**
1