COSC480 Project Proposals for 2011

This is a list of suggested project proposals for COSC480 projects. If you have a project of your own you would like to undertake instead then you must discuss it with me or one of the staff. In the past we have often created special projects so that students can follow their interests. Additionally, many of the staff members have other interests that might be suitable for a project – you can find out about these by talking to them! In any case, suggesting a project that is not part of this list requires the agreement of a potential supervisor.

- Select (at least) three projects that you think will interest you.
- Meet with the faculty members who are offering those projects in order to discuss the possibility of taking them up (this is an **absolute** requirement – see below.)
- Rank three of them in preference order on the project request form and return it to the main office by **March 4**. Include both the project number and project title (for verification!)
- Send an email with your project preferences to me (malbert@cs.otago.ac.nz).
- You will be advised early in week 2 of your project assignment.

Michael Albert
400 level project coordinator

Meeting with possible supervisors is important. We try to give students their first choices but we have to spread the work among supervisors and match projects to your particular abilities. If you make a choice without seeing the supervisor, we will probably ignore that choice when doing the allocation.

1. **Digital music**
Andrew Trotman (andrew@cs.otago.ac.nz), Richard O'Keefe (ok@cs.otago.ac.nz)
The Wikipedia claims that digital music dates to the 1960s. In fact it dates to earlier than the 1860s when such devices as the barrel organ and pianola were invented. But we can't play old digital music, whether from the 1960s or the 1860s, any more because we don't have the necessary digital devices. In this project we will build an electronic pianola and use it to convert some old digital music into MIDI files so that we can play the music on our modern devices.

2. **Memory errors**
Andrew Trotman (andrew@cs.otago.ac.nz), Richard O'Keefe (ok@cs.otago.ac.nz)
Memory errors in C and C++ are some of the hardest errors to find. Luckily we can use tools such as Purify and Valgrind to help us find such errors. Unluckily we are migrating to 64-bit operating systems and many of these tools just don't work 64-bit. In this project we'll take a look at the current state of the art in memory checkers. We'll test each tool by running it over a collection of research software from within and outside the department. Which errors do they find? Which do they not? Which tools should we adopt for departmental use?

3. **Public domain search engines suck**
Andrew Trotman (andrew@cs.otago.ac.nz), Richard O'Keefe (ok@cs.otago.ac.nz)
We have commercial search engines including: Google, Microsoft Bing, Yahoo!, and others.

Then we have academic search engines including: Terrier, Zettair, Lemur, and others. Whatever it is that the Wikipedia uses, it sucks! In this project we will compare the performance of the commercial search engines to those of the academic search engines and measure the performance of each (using the Wikipedia). Using a pre-generated set of queries (to which the answers are known) we will show who has the state-of-the-art in search techniques for this one valuable resource. Once we know this we will examine the algorithms being used and experiment with methods of improving their performance further.

4. **Implementing a TDMA MAC protocol for wireless sensor networks**
Haibo Zhang (haibo@cs.otago.ac.nz)
Wireless sensor networks (WSNs) are being widely employed in industry due to their advantages with respect to comfortability, maintenance and installation. Since many industrial applications have stringent requirements on network delay and reliability, designing an efficient MAC protocol for reliable and real-time data transmission in WSNs still remains a challenging issue. As TDMA MAC protocols have the advantages of providing collision-free data transmission, the goal of this project is to develop a TDMA MAC protocol for WSNs. In this project, you will learn how to program with Contiki, the most popular operation system for WSNs, and have the chance to play with sensor hardware.

5. **Routing module for simulation of WirelessHART networks**
Haibo Zhang (haibo@cs.otago.ac.nz)
In a previous project, we have developed a simulator using Java and Matlab for simulation of WirelessHART networks. This project involves adding a routing module to the simulator. In this module, a set of routing protocols such as source routing, graph routing and delay-guaranteed routing will be implemented.

6. **Learning to recognise grasp affordances**
Alistair Knott (alik@cs.otago.ac.nz)
We can pick up a cup in a variety of ways: by its handle, by its rim, by its sides and so on. When we look at an object, we are able to identify the different ways it can be grasped straight away, using a function which maps the visual representation of the cup onto a set of possible grasp states. This function is learned during infancy: infants explore different ways of grasping objects, and when they find a successful grasp, they train the function to predict this grasp from the visual representation of the object. In this project, you will model this training process. A current MSc student (Tim Neumegen) has built a simulated 3D hand/arm which can be controlled manually, and can be made to reach and grasp simulated objects.

Your task is to use this simulation to train a function which can predict the different grasps possible on a given object from a visual representation of the object. The hand/arm simulation is written in Java, and uses a physics engine called Bullet, with OpenGL as a graphics engine. But most of your work will probably be in computer vision: some early visual processing, and some neural network training.

7. **Modelling surface-based sentence interpretation**
Alistair Knott (alik@cs.otago.ac.nz)
People suffering damage to a brain region called Broca's area have difficulty with language. The area has something to do with syntactic processing: patients with damage to Broca's area can understand and produce single words, but have difficulty understanding and producing whole sentences. However, while they have problems producing any kind of sentence, their understanding of simple sentences is actually quite good: there is evidence for a simple sentence interpretation mechanism in a separate area of the brain, which learns to map sequences of words directly to semantic representations. In this project, you will model this simpler form of processing. The main tool you will use is a simple recurrent network (SRN). You will build a SRN which learns to map sentences onto semantic representations. The aim is to reproduce the residual sentence interpretation abilities of Broca's aphasics, as well as some of the mistakes they make.

8. **Games with video interaction**
Geoff Wyvill (geoff@cs.otago.ac.nz)
Since 2005, we have been demonstrating a game played with an audience in a lecture theatre. A big screen shows the audience in mirror image but there are other objects in the 'mirror world'. Players interact with these objects and the only input is from the camera on the audience. This year, a summer scholarship student, improved the game by connecting a faster camera and fixing some minor bugs. The idea of this project is to use the improved environment to create an interesting game or activity that can be played in an ordinary room rather than a lecture theatre.

Special note from Geoff Wyvill: I am retiring this year and I do not intend to supervise as many projects as I have in the past. I do realise that a lack of graphics projects could be a disappointment to some students. So I am offering some. However, I will not take anyone who has not discussed it with me first. So don't put in a choice for one of these unless you have seen me. Email geoff@cs.otago.ac.nz to make an appointment. Don't leave it until Friday!

9. **The new Watching Window**
Geoff Wyvill (geoff@cs.otago.ac.nz)
Our Watching Window display uses cameras to track head and eyes and displays an image from the users point of view. We have new cameras with fisheye lenses and a 42 inch lenticular stereo display. This is a screen that can present a stereoscopic 3D image to the user without the use of special glasses. The software needs an overhaul to make it more reliable and to make better use of the new equipment. Learn all about the Watching Window and get it working properly. (See note above.)

10. **Perception of vibrato**
Geoff Wyvill (geoff@cs.otago.ac.nz)
Vibrato is a variation of pitch used by musicians to decorate notes. The pitch of a note with vibrato is perceived as being somewhere between the highest and lowest pitches in the note, but where exactly? Devise a set of experiments to settle this question by getting musicians and others, to estimate the pitch of a note with vibrato. This project was attempted in 2007 but the results were inconclusive. Build on the experience of the first attempt. (See note above.)

11. **The dome display**
Geoff Wyvill (geoff@cs.otago.ac.nz)
We have an experimental screen in the form of a fabric dome three metres wide. So far, we have used it for two projects in virtual reality: a shopping cart simulator and a hang glider simulator. Build a new dome application. If successful, this can be demonstrated at the International Science Festival in Dunedin in July 2012. (See note above.)

12. **Dynamic public transport route planning for Dunedin**
David Eyers (dme@cs.otago.ac.nz)
A number of the world's large public transport authorities provide journey planning tools to help travellers' efficiency. This has generally been in the form of web applications, although increasingly applications for mobile devices are being deployed. Mobile devices have more restricted interfaces, but can also provide pertinent information such as location data. The aim of this project is to implement a journey planning tool for use within Dunedin.

13. **Spatial Prolog state explorer**
David Eyers (dme@cs.otago.ac.nz)
Prolog is a programming language that was developed in the 1970s. Its language semantics are beautifully concise: a basic Prolog engine can be written in a surprisingly small amount of procedural code. Because Prolog programs - along with testing data - can be very terse, and because of the way in which the Prolog language unifies the concept of data and the concept of code, it is a candidate with better-than-average appropriateness for having its internals dynamically visualised. This type of dynamic visualisation of the simple use of a programming language might prove to be a useful teaching tool for those trying to understand how computers work. The aim of this project is to produce a system that allows users to visually explore the information contained within a Prolog database, and to watch the progress of the evaluation of queries made against that database.

14. **Private Dropbox**
David Eyers (dme@cs.otago.ac.nz)
Products such as Dropbox provide highly useful, effective and convenient tools for synchronising data between multiple devices. However they have the downside of being run somewhere on the cloud, using server-side software that you don't have access to. Storing data in peer-to-peer networks avoids relying on a (logically) centralised service, however it becomes much harder to offer any quality of service guarantees. The aim of this project is to develop a file synchronisation tool that provides an intermediate step between peer-to-peer and cloud-based services. To address data privacy concerns, it should include capabilities for explicitly controlling the subset of a distributed storage system in which particular datasets can be replicated. It will also facilitate the encoding of policies about the costs, speeds and appropriate scheduling of the use of particular communication links.

15. **Avoiding the dark side**
David Eyers (dme@cs.otago.ac.nz)
Newcomers looking to settle in Dunedin are often advised to consider how much light their place of abode will receive throughout the year. The aim of this project is to produce an interactive mapping tool that can approximate the way in which shadows move over the suburbs in Dunedin at different dates and times.

16. **File provenance tracker**
David Eyers (dme@cs.otago.ac.nz)
Multi-user operating systems provide ways to control who (or what) is allowed to access and/or modify data within their filesystems and processes. Since the time of their original design, owing to the wide-spread deployment of multi-user computing, there is an increasing need for manageable auditing of access, in addition to preemptive access control restrictions. In some cases, system administrators could avoid costly micromanagement of tightly controlled user groups by instead auditing the actual usage of more permissive user groups. However, most operating systems do not provide a convenient means to see who has actually accessed or modified a file, as opposed to who could potentially have done so. The aim of this project is to build a framework that can audit and conveniently report on who accesses or modifies files in a multi-user operating system, with adjustable control over how much of this information is maintained.

17. **Simulator of a spiking neuron**
Lubica Benuskova (lubica@cs.otago.ac.nz)
Nerve cells in the brain, called neurons, send messages to each other via short electric impulses called spikes. There is a class of mathematical models of neurons that are called spiking models of neurons because like their biological counterparts, they use spikes as input and output. The goal of this project is to make an interactive simulator of neuron, in which we can change values of parameters and observe visually the impact on input-output function of a neuron. Essentially, this means to implement a set of differential equations. These equations have a certain set of variables and parameters. Upon change of the value of these parameters, we want to see, how it affects the neuron output. A description of the model can be found at: `http://www.izhikevich.org/publications/spikes.htm`. There you can find also a Matlab based simulator of this model with some limited usage.

18. **Scratch based interfaces**
Brendan McCane (mccane@cs.otago.ac.nz)
Stethoscopes (those hearing things that doctors use) can be hooked up to microphones to provide very sensitive audio input devices. Sensitive enough that scratching a surface can easily be detected. This project is to develop the software for a dual stethoscope system to act as a mouse and gestural input device.

19. **Web based curriculum vitae database**
Brendan McCane (mccane@cs.otago.ac.nz)
Here at Otago, academics have to maintain a CV (ostensibly in MS Word). Unfortunately, there are different formats needed for different applications (promotion, grant applications, PBRF etc). The goal of this project is to develop a web-based CV database that will hold all relevant data and be able to produce printable output in different formats. This is largely a development project, but evaluation (maintenance, efficiency etc) of various different implementation strategies will be required.

20. **Robust feature matching**
Brendan McCane (mccane@cs.otago.ac.nz)
To investigate and implement techniques for luminance mapping and feature matching that are robust enough to match across multiple exposures from different cameras under different lighting conditions. Robustly matched feature points can then be used to reconstruct 3D scene geometry.

21. **Quantifying conceptual density in text**
Anthony Robins (anthony@cs.otago.ac.nz), Alistair Knott (alik@cs.otago.ac.nz)
Can we identify the density of connections between individual concepts in a body of text? In other words, can we identify discrete concepts, and quantify the relationships between them? This project will involve investigating existing natural language processing tools, and perhaps developing our own.

22. **Mining problem code data**
Anthony Robins (anthony@cs.otago.ac.nz)
We have a dataset consisting of thousands of counts of problems experienced by students in our introductory programming course. So far only a preliminary analysis has been conducted. What else lies in the data? Can we predict how well a student will do on the basis of the problems that they meet? Tools from machine learning and data mining will be relevant.

23. **Attractor spaces in Hopfield nets**
Anthony Robins (anthony@cs.otago.ac.nz)
Hopfield networks (a kind of neural network) have dynamic behaviour that can be characterised in terms of gradient descent in a multidimensional attractor space. We know a fair bit about the structure of such spaces. This project will involve implementing and exploring a Hopfield type network to further develop our understanding of its dynamic behaviour.

24. **Neural network models of memory**
Anthony Robins (anthony@cs.otago.ac.nz)
Artificial neural networks have been used to model many aspects of human memory. This project will involve reviewing the existing literature, and implementing, testing, and possibly extending an existing model or models. The review may focus on the representation of conceptual categories and the process of categorisation.

25. **Standard conformance assessment**
Richard O'Keefe (ok@cs.otago.ac.nz), David Eyers (dme@cs.otago.ac.nz)
Smalltalk is the simple, powerful, consistently object-oriented programming language that launched OOP, GUIs, and IDEs back in 1980. It is also where modern unit testing and refactoring originated. There is an ANSI standard for the core language and libraries. We have Squeak, Pharo, and Gnu Smalltalk, all free, and community/ academic copies of VisualWorks, VisualAge, and Dolphin Smalltalk. Just because there is a standard doesn't mean everyone follows it. The project is to take some existing unit tests for the Collection classes, increase their coverage, try them in as many of the implementations as practical, and assess the results. There are known to be some deviations and outright bugs. Are there any more? Is there any point in fixing them? Do the deviations affect portability? Why might such deviations exist?

26. **A date library for the Māori calendar**
Richard O'Keefe (ok@cs.otago.ac.nz)
Many programming languages these days have a Date data type. Commonly it supports the proleptic Gregorian calendar only. (the Gregorian calendar projected into the past.) What people sometimes call the Māori calendar is just the Gregorian calendar with Māori names for months and days, and even C can handle that. The traditional Māori calendar is a lunisolar one triggered by observation. This project involves searching the literature to find how to predict the rising of Matariki, how to predict the cycle of the moon, and then putting this together to convert between absolute day numbers and Māori dates. Since different tribes named months differently, your code will need to be easy to customise. You may use any programming language you choose.

27. **Puzzling logically**
Michael Albert (malbert@cs.otago.ac.nz)
Many currently popular logic puzzles (Sudoku, Kakuro, Kenken, Nurikabe) require finding the unique completion of some partial configuration. This project will concentrate on some of the following issues:

- What is known about the complexity of these types of puzzles?
- In practice, how efficiently can we solve/check specific puzzles of these types?
- How can we generate "interesting" examples of these types?
- How can we generate entirely new logic puzzles of this family?

28. **Movement monitoring using wireless sensors**
Michael Albert (malbert@cs.otago.ac.nz), Haibo Zhang (haibo@cs.otago.ac.nz), Brendan McCane (mccane@cs.otago.ac.nz)
The use of wireless devices with internal kinematic sensors to detect and report on movement is a fast-growing area of the health care and athletic training market. However, current equipment is both specialised and expensive. It seems that off the shelf equipment, together with an appropriate communications protocol, biomechanical modelling, and processing of the incoming data, could well provide a more flexible, extensible and economical solution. That's a tall order – but in this project a student will address some parts of this problem.

Note: Because of the potential scale of this project it could be offered to more than one student. Participants would work in cooperation, but on different aspects of it.