HONOURS PROJECTS OFFERED
2012

Contents

1. Mobile Craft and Curio e-Commerce Platform

Proposer: *Gary Marsden*

Abbreviation: *mCurio*

Brief Description: *The aim of this project is to empower artists and craft workers to sell their product on-line. The system would consist of two components – a mobile system that lets users upload details of items for sale and a back-end system that generates an e-commerce web site and keeps track of sales and stats. This project will be conducted in conjunction with Rhodes Computer Science Department who have been conducting the research with a target community and have partially developed a server-side platform.*

Computer Science Content: *Web programming, mobile programming, e-commerce, web services, mobile web*

Specific Learning Outcomes: *Design, HCI, ICT4D*

Skills Required by Team as a Whole:

- ***Theory:*** *None*
- ***Implementation:*** *Android/Java and server-side Java/JSON*
- ***Other:*** *Designing a system for non-literate users*

Facilities Needed: *Mobile Android handsets*

Supervision: *Besides me, there is a full time PhD student at Rhodes working on this who will give this group near unlimited support. There are also developers, server side, resources at Rhodes, but their commitment is less.*

Number of Students: *2*

2. Big Board Lite

Proposer: *Gary Marsden*

Abbreviation: *BBLite*

Brief Description: *For several years we have been developing the Big Board system, to distribute information to mobile handsets for free. This system has gone through several iterations. Two years ago a student built a mobile version. At that time, the image recognition software ran too slowly on the hardware. Now we want to build a system on Android that has a robust image recognition system and distributes data reliably.*

Computer Science Content: *Image recognition and Interface programming under Android.*

Specific Learning Outcomes: *Interface design; performance testing of algorithms; Android*

Skills Required by Team as a Whole:

- ***Theory:*** None
- ***Implementation:*** *Understanding the Android Bluetooth stack (not easy); Implementing SIFT or SURF on Android*
- ***Other:*** *Interface Design*

Facilities Needed: *Android mobile handsets*

Supervision: *I have been working on this project for five years and it has massive international recognition – in fact the UN is negotiating with us to adopt it. Microsoft co-developed it, so they are also providing some support.*

Number of Students: *2. At a push, 3. But 2 would be best.*

3. Mobile Web Server

Proposer: *Gary Marsden*

Abbreviation: *Grout*

Brief Description: *Windows mobile has this neat idea of a tiled interface; tiles reflect some state or data the user is interested in. At the moment, these tiles reflect data on the internet or on the device. We wish to extend this to take into account other devices in the area. So, on the client handset there are a number of tiles representing friends/other handsets. On the server handsets, users dump any files they wish to share into a public folder (new music, video clips etc.) On the client handset, whenever a friend is near, the tile starts showing the files that they have made available for upload. The client can then choose to download them to their own handsets.*

Computer Science Content: *User interface challenges, device discover and ad-hoc networking.*

Specific Learning Outcomes: *Interface design, mobile networking.*

Skills Required by Team as a Whole:

- ***Theory:*** *None*
- ***Implementation:*** *Programming Windows Mobile*

Facilities Needed: *Windows mobile handsets*

Supervision: *I am working on this with Microsoft Research in order to create a major research proposal around the idea. So this is an active area for me and some researchers at Microsoft. I also have 2 MSc students and one PhD working in the area.*

Number of Students: *2*

4. Parallelization of a Hybrid Optimization Algorithm

Proposer: *Michelle Kuttel*

Abbreviation: *PAROPT*

Brief Description: *Heuristic optimisation algorithms like simulated annealing and Genetic Algorithms are powerful and flexible and are playing an ever more important role in modern life. In both optical and radio astronomy, these algorithms are relevant to the design of telescopes and surveys, the selection of targets, image reconstruction and a multitude of related problems. In particular, the planned Square Kilometre Array radio telescopes will necessitate a new generation of optimisation methods.*

A new algorithm, HYBRID, has been shown to significantly outperform standard algorithms by combining elements of three optimization strategies: MCMC, simulated annealing and particle swarm optimisation.

This project will look at efficient ways of implementing HYBRID on GPUs or multicore processors. The project also has scope for developing HYBRID in new directions, which may lead to even more significant speedups. HYBRID should be particularly useful in any optimization problem with a very large number of dimensions.

References

** http://arxiv.org/abs/astro-ph/0602338 (The original HYBRID paper)*

** J. Kotze, PhD thesis UCT (Extensions to the HYBRID algorithm)*

Computer Science Content: *Optimization algorithms, parallelization and multi-threading, high performance computing.*

Specific Learning Outcomes: *You will learn to implement profile and benchmark a parallel algorithm, as well as a fair bit about parallel programming methods and technologies. You will also learn about optimization algorithms, which have broad applicability.*

Skills Required by Team as a Whole:

- ***Theory:*** *Students should attend the parallel programming course for the necessary background in multithreading. Students must also research different optimization algorithms. One student could focus on the former and the other the latter.*
- ***Implementation:*** *C++ or Python*

Facilities Needed: *Multicore Computer and/or access to CUDA enabled GPUs*

Supervision: *Weekly meetings with supervisor, meetings as required with co-supervisor Bruce Basset (African Institute for Mathematical Science, South African Astronomical Observatory and the Mathematics and Applied Mathematics Department at UCT)*

Number of Students: *2 (or 3)*

5. Glycano: Interactive sugar builder

Proposer: *Michelle Kuttel*

Abbreviation: *Glycano*

Brief Description: *We have an on-going project to develop scientific software tools to aid research into the structure of carbohydrate molecules (which play key roles in disease). A previous Honours project developed CarbBuilder1 – a system for building 3D structures of carbohydrates from 2D specification. This project will extend this work, developing a tablet app frontend to CarbBuilder to enable touch-based building of, and interaction with carbohydrate molecules. This app will have both educational (What do carbohydrates look like? What are the possible structures?) and research applications. The functionality of existing tools, such as GlycanBuilder2, will be assessed so as to improve on current web-based designs and produce a polished final app. In addition, two current SURE projects are investigating aspects of system design, results of which should be incorporated into the app design. This is essentially a design and implementation project, but there is considerable scope to expand the capabilities of CarbBuilder as well as develop the app as an educational game, along the lines of recently published games for building protein structures.*

References:

** CarbBuilder: an adjustable tool for building 3D molecular structures of carbohydrates for molecular simulation, Michelle Kuttel, Yue Mao, G¨oran Widmalm and Magnus Lundborg, Proceedings of the 7th IEEE International Conference on e-Science, 5-8 December 2011, Stockholm, Sweden, pages: 395-402.*

** (http://code.google.com/p/glycanbuilder*

** Predicting protein structures with a multiplayer online game, Seth Cooper, Firas Khatib, Adrien Treuille, Janos Barbero, Jeehyung Lee, Michael Beenen, Andrew Leaver-Fay, David Baker, Zoran Popovic & Foldit players, NATURE|, Vol 466, 5 August 2010, 756-760*

Computer Science Content: *Interface and software design, app development, scientific visualization*

Specific Learning Outcomes: *You will learn about principle of visualization and interface design, how to test visualizations for efficacy, how to interact with clients and produce useful scientific software.*

Skills Required by Team as a Whole: *One team member should be interested in design, one in tablet programming.*

- ***Theory:*** *Absolutely no prior experience with chemistry is required. However, you will have to be willing to learn the basics of molecular structure (which is useful knowledge!).*
- ***Implementation:*** *Implementation will be of average difficulty for an Honours project. The emphasis will be on an interactive design process to obtain a really useful and user-friendly product. New, innovative ideas are welcomed.*

Facilities Needed: *Samsung Tablet, Standard PC/Laptop*

Supervision: *You will have weekly meetings with Michelle, together with remote Co-supervision by Göran Widmalm (University of Stockholm, Sweden).*

Number of Students: *2 or 3 (4 possible)*

6. Visualization of protein interaction networks

Proposer: *Michelle Kuttel*

Abbreviation: *PROTNET*

Brief Description: *Biological systems are made up of a number of components, including nucleotides, proteins and small molecules. Proteins are the key players in most biological processes but don't work in isolation. In order to study the full context of biological systems, we need to visualize the complete set of proteins and how they interact with each other in the cell. For TB alone, the protein interaction data includes 4136 nodes (proteins) and nearly 60,000 edges (interactions), making the analysis and visualization of the network complex. There are a number of freely available tools for network visualization, e.g. Cytoscape, that allow overlaying of metadata and interactive viewing (zooming in and out, etc), but their capabilities are limited to viewing a single or few metadata types at a time and the data needs to be exported from a source and imported into the tool. Ideally we would like a visualization tool that can handle complex networks and sets of networks, can handle visualization of different metadata and that works in a searchable, interactive, web interface.*

Computer Science Content: *Interface and software design, scientific visualization, bioinformatics.*

Specific Learning Outcomes: *You will learn about principle of visualization and interface design, how to test visualizations for efficacy, how to interact with clients and produce useful scientific software.*

Skills Required by Team as a Whole:

- ***Theory:*** *Absolutely no prior experience with chemistry is required. However, you will have to be willing to learn the basics of protein interactions and interaction metadata, as well as research network visualization.*
- ***Implementation:*** *Implementation will be of average difficulty for an Honours project. The emphasis will be on an interactive design process to obtain a really useful and user-friendly product. New, innovative ideas are welcomed.*

Facilities Needed: *Standard PC/Laptop*

Supervision: *You will have weekly meetings with Michelle, together with co-supervision as required from Assoc Prof Nicola Mulder, Computational Biology Group, IIDMM, UCT.*

Number of Students: *2*

7. Customising a Learning Management System

Proposer: *Sonia Berman*

Abbreviation: *VULAMOBI*

Brief Description: *This project will investigate the presentation of LMS (Learning Management Systems) in new ways, and in particular for both smart phones and low-end cell phones. The system will be tested on specific parts of Vula, but should aim to use a generalizable approach suitable for another LMS as well. Our current Vula (Sakai) system automatically detects access from a mobile device, but only adapts accordingly up to a point and not within the various Vula tools. Our Vula also presents a single uniform view of course sites to everyone, and does not provide alternatives to suit individuals. If this group comes up with an exciting fresh look at Vula there is an active Sakai community where the product could be circulated.*

Computer Science Content: *Mobile programming, HCI, web services.*

Specific Learning Outcomes: *Some aspects have a software-engineering focus (concentrating on analysis, design and development of the system) others an experimental focus (concentrating on designing and evaluating the interfaces produced).*

Skills Required by Team as a Whole:

- ***Theory:*** *No special requirements here.*
- ***Implementation:*** *This involves a combination of software engineering, programming and human interaction skills.*

Facilities Needed: *Mobile phones*

Supervision: *Weekly meetings with the supervisor. Stephen Marquard from Vula will be co-supervisor.*

Number of Students: *2-4*

8. Paused? Engage!

Proposer: *Sonia Berman*

Abbreviation: *ENGAGE*

Brief Description: *To improve pass rates, students must engage with course material more often. This project will investigate and develop mechanisms for making Sakai (Vula) a learning system rather than a management system. The aim is to build tools that enable students to engage with their work in a quick and easy, non-disruptive way. Students would achieve bonus marks for their class record according to how much they use your tools via mobile or Web interfaces. These should be designed for engaging in short snippets during "pauses" between lectures or other activities. Some examples might be submitting MCQ questions and answers, answering questions in a forum, collaboratively building an ontology/mindmap/wiki of course material, etc. One student will develop the engagement system for a small class, by building tools that interface with Sakai. The second student will focus on scalability i.e. handling many submissions by hundreds of students. This will require a mechanism to help tutors detect misuse of the system, and to help direct students to appropriate contributions.*

Computer Science Content: *Databases, mobile programming, HCI, AI*

Specific Learning Outcomes: *Some aspects have a software-engineering focus (concentrating on analysis, design and development of the system) others an experimental focus (evaluating usability and scalability techniques respectively).*

Skills Required by Team as a Whole:

- ***Theory:*** *No special requirements here.*
- ***Implementation:*** *This involves a combination of software engineering, programming and human interaction skills*

Facilities Needed: *Mobile phones*

Supervision: *Weekly meetings with the supervisor. Stephen Marquard from Vula will be co-supervisor.*

Number of Students: *2*

9. Threat Models in Social Networks

Proposer: *Anne Kayem*

Abbreviation: *HACKMI2*

Brief Description: *In many applications, security is typically incorporated at the end of the design cycle. The consequence is that many systems are deployed with security mechanisms that have not been checked as rigorously as the rest of the system. Scandals such as the one that occurred in July of 2011, where security consultant (Ron Bowles) used a piece of code to collect personal data off Facebook and publish it on Pirate Bay (a popular file sharing site), only serve to emphasize the need for more thorough security and privacy verifications.*

Threat modelling is useful in applying a structured approach to system security. With threat modelling one can identify and categorise potential security vulnerabilities in a system and then develop countermeasures accordingly. Approaches to threat modelling include:

- ➔ *The attacker centric model that is centred on the attacker's goals and motivations for breaking into a system. In this case, we want to evaluate how the attacker would achieve this and why.*
- ➔ *The software centric model that is aimed detecting vulnerabilities in the system's design. In this case the idea is to step through the different components of the system and find the weaknesses that an attacker might exploit.*

Having a blueprint of potential threats is useful, from the system designer's view point, because potential attack scenarios as well as the countermeasures can be simulated before the application is deployed. However, until recently, not much consideration has been given to comparing threat models or evaluating their efficacy in dealing with threats. This project is aimed at developing a framework to compare and evaluate different threat modelling approaches. We will use an open source social network as a case study for evaluating the threat modelling approaches and implement an "intelligent" multi-agent system to provide countermeasures for potential attacks.

Additional Reading:

- *Bedi et al, "Avoiding Threats Using Multi Agent System Planning for Web Based Systems", Computational Collective Intelligence, Semantic Web, Social Networks and Multi-agent systems. Lecture Notes in Computer Science, pp. 709-719, Vol. 5796/2009.*
- *Mauw and Oostdijk, "Foundations of Attack Trees", Information Security and Cryptology, Lecture Notes in Computer Science, 2006, Volume 3935/2006, 186-198*
- *http://www.pattayadailynews.com/en/2010/07/29/facebook-security-breach-private-details-published-on-pirate-bay/*
- *http://en.wikipedia.org/wiki/The_Pirate_Bay*

Computer Science Content: *Information Security (Threat Modelling, SQL Injection...), Multi-agent Systems (Design and implementation), Decision Trees and Neural Networks.*

Specific Learning Outcomes: *Security System Design, Comparative evaluation of threat models, experimental analysis.*

Skills Required by Team as a Whole:

- ***Theory:*** *None*

- ***Implementation:*** *Program manipulation and analysis.*
- ***Other:*** *A passion for identifying program vulnerabilities*

Facilities Needed: *regular PC*

Supervision: *Co-supervised by Rogan Dawes (SensePost). Monthly telephonic or Skype meetings with Rogan Dawes. Weekly meetings with Anne Kayem.*

Number of Students: *2 (but 3 is fine)*

10. Procedural Modelling of Realistic Trees

Proposer: *James Gain*

Abbreviation: *ProcTree*

Brief Description: *Lindenmayer systems (or L-systems) are a grammar-based method for creating procedural computer graphics content. Most commonly this involves creating the geometry of trees and plants for games and Visual Effects. Each L-system rule set encodes a particular species of plant and can be used to generate a potentially wide range of individual trees representative of that species.*

Unfortunately, little attention is paid to the graphical (as opposed to structural) realism of the resulting trees. The leaves, trunk and bark of a typical procedural tree do not stand up to close scrutiny. This project will focus on improving the realism of these aspects using existing techniques from computer graphics (subdivision surfaces and texture synthesis).

Reference: Prusinkiewicz, P. and Lindenmayer, A. The Algorithmic Beauty of Plants. Springer Verlag. http://algorithmicbotany.org/papers/#abop

Computer Science Content: *Computer Graphics (procedural methods, rendering), Image Processing (texture synthesis), Human-Computer Interaction (interfaces)*

Specific Learning Outcomes: *integration with existing graphical systems, iterative system development*

Skills Required by Team as a Whole: *Each project component (subsystems for trunk, leaves and bark) requires an initial introductory level understanding of computer graphics and interface design.*

- ***Theory:*** *moderate (advanced computer graphics)*
- ***Implementation:*** *moderate – difficult (subdivision surfaces for geometry, texture synthesis for bark, procedural generation for leaves, sketching interface for overall control)*

Facilities Needed: *Access to PC with reasonable graphics card, C++ compiler, code from previous tree sketching project, SoftImage license (provided by TriggerFish Animation)*

Supervision: *James Gain. Weekly meetings with supervisor expected, occassional attendance and presentation at research group meetings may also be required. This project includes a compulsory 1 month internship, at Triggerfish, in the June/July period.*

Number of Students: *3*

11. A Crowd Simulation System for Animated Films

Proposer: *James Gain*

Abbreviation: *CrowdSim*

Brief Description: *It is common for modern films to involve computer-generated crowds numbering in the hundreds of thousands. While each member of the crowd is not particularly sophisticated, their emergent behaviour can be compelling. There are, however, two significant issues: existing solutions (such as Massive) tend to be proprietary and the computational cost of such simulations is daunting.*

This project entails developing a crowd simulation system for AI agents whose individual behaviour is determined by a simple rule-based system (such as decision trees). An authoring interface will be necessary for high-level crowd coordination (for example, to indicate favoured routes through an environment) and specification of agent rules. Computationally costly components of the system will be accelerated using Graphical Processing Units.

Additional Reading – Massive Software http://www.massivesoftware.com/

Computer Science Content: *Artificial Intelligence (agent-based crowd simulation, decision trees), Computer Graphics (computer animation), Human-Computer Interaction (interfaces for artists)*

Specific Learning Outcomes: *integration with existing graphical systems, iterative development for Graphical Processing Units*

Skills Required by Team as a Whole: *Each project component – authoring interface, agent-based crowd system, GPU acceleration requires a different blend of skills.*

- ***Theory:*** *easy – moderate (agent-based artificial intelligence, swarms, computer animation, graphical interfaces)*
- ***Implementation:*** *moderate – hard (decision trees for agent behaviour, GUI for high level crowd control, programming for GPU clusters)*

Facilities Needed *Access to PC with reasonable graphics card, C++ compiler, SoftImage license (provided by TriggerFish Animation), Access to GPU cluster.*

Supervision: *James Gain and Patrick Marais. Weekly meetings with supervisors expected, occasional attendance and presentation at research group meetings may also be required. This project includes a compulsory 1 month internship, at Triggerfish, in the June/July period*

Number of Students: *3 (2 accepted if GPU acceleration component is discarded)*

12. Kinect Virtual tours for Heritage sites

Proposer: *Patrick Marais*

Abbreviation: *KINECT*

Brief Description: *This project is aimed at providing an interactive system for accessing and displaying large 3D models of heritage sites, along with other data such as panorama images and floor plans. The input will be gesture-based, and use a Microsoft Kinect sensor. The user should be able to view the full 3D model, zoom into regions for a closer look, and query the model to obtain additional metadata and GIS data. The system will be used by the Zamani (****http://www.zamani-project.org/****) project to increase public access to their data, which includes laser-scanned models of many heritage sites in Africa.*

The system will require students to familiarise themselves with the Kinect API and DirectX. There will be front-end work (rendering, gesture input and parsing), as well as back-end work (data structures and algorithms to manage model data, including perhaps level-of-detail schemes).

Additional Reading – Massive Software http://www.massivesoftware.com/

Computer Science Content: *Rendering; HCI; data structures and algorithms; algorithms for efficient graphics.*

Specific Learning Outcomes: *Design, implement and test algorithms and data structures based on a problem spec.*

Skills Required by Team as a Whole: *The project will require students willing to learn new APIs for both gesture recognition (Kinect) as well as rendering etc. To allow for efficient display of large 3D model data, it may be necessary to explore level-of-detail schemes too.*

- ***Theory:*** *The theory in this project will be limited to understanding concepts in rendering and gesture/interface design. The Kinect software should handle the most challenging computer vision/recognition tasks.*
- ***Implementation:*** *Moderate to hard. There will be a lot of development work for this project. The major components will be: rendering, gesture interpretation and design; back-end resource/model management. There may, if time permits, also be scope to explore web-based access to remotely served model data.*

Facilities Needed: *Standard lab machines and Development environment. A Kinect sensor will be made available for the project, as well as appropriate Zamani model data*

Supervision: *Patrick Marais and James Gain will supervise this project, and provide expertise on computer vision, image processing and computer graphics; Prof Heinz Ruther and Mr Christoph Held from Zamani will be called upon for expertise related to heritage digital data.*

Number of Students: *3*

13. Automated Counting of Cape Fur Seal Pups on Digital Aerial Photographs

Proposer: *Patrick Marais*

Abbreviation: *SEALS*

Brief Description: *The Cape fur seal population can only be practically monitored by aerial photographic censuses of all breeding colonies. The pups are counted manually from print outs or electronically with a tally counter. Pups are crucial as they are the only age group present at all times for the full duration of the breeding season. These traditional techniques are both labour intensive and expensive. The accuracy of such manual counting has been questioned and error margins are large. Furthermore, with technological advancements, it has been proven that electronic counting (from aerial survey digital images) has yielded significantly more accurate results.*

An automated counting system is required that can take into account different ground substrate types, time of day and survey altitude issues. Recent developments in marine mammal monitoring, such as GPS tagging of photographs and using unmanned aerial vehicles can help to achieve this goal.

The system will require components to perform seal detection and counting, which will involve learning algorithms and image processing, as well as a system to visualize/display results. Some preliminary work on this project was conducted in 2011 and should be used a starting point when planning this new project phase

Computer Science Content: *This project will require techniques from image processing, computer vision and AI. Specifically, those algorithms dealing with object recognition/segmentation will need to be explored in some depth to develop a feasible solution.*

Specific Learning Outcomes: *Software design; algorithm design; validation*

Skills Required by Team as a Whole: *This project requires students with a strong programming background and an interest in computer vision/AI. A fair amount of reading will also be required to gain understanding of the basic techniques required.*

- ***Theory:*** *The theory behind object recognition can be quite complex. The specific features of the images (resolution, terrain changes, occlusion of seals) will make this very challenging.*
- ***Implementation:*** *The implementation will require image processing tools to be developed, as well as object recognition algorithms and data structures.*

Facilities Needed: *The computer hardware in the honours lab should be adequate; open source software/libraries can be used for some parts; data will be provided by the client.*

Supervision: *Dr Audrey Mbogho will serve as co-supervisor, and Mr Mduduzi Seakamele from Oceans and Coasts Research is the client. Audrey and Patrick will provide help with image processing and segmentation techniques, and Mduduzi will provide expertise on seal classification and prior work.*

Number of Students: *3*

14. High Fidelity Compression of MeerKat Correlator Data

Proposer: *Patrick Marais*

Abbreviation: *MeerComp*

Brief Description: *The MeerKAT radio telescope will produce vast quantities of data from its antenna. The antenna produces a data stream in the hundreds of Gb/s range. All this data has to be processed by special hardware (FPGA correlators) to produce data that can be used for astronomical measurements. The correlator stage is followed by a GPU processing phase which can operate on the data to transform it in interesting ways, prior to imaging. The biggest challenge currently lies in the correlator data processing stage - the data bandwidth coming out of the correlators is too high for the hardware downstream. This suggests compressing this data by discarding 'redundant data'.*

Although the correlation stream does not seem a good candidate for compression, lacking obvious redundancy, some preliminary work by the MeerKAT science team suggests that even simple heuristics can reduce the data size by a factor of two with minimal loss of fidelity. This is possible because the entire dynamic range is not, on average, required.

The newly developed algorithms will need to be simple and to support an efficient GPU shader implementation. The compression algorithm will need to map well to simple FPGA hardware (which can be simulated) and the decompression algorithm will need to run efficiently on a GPU.

Successful completion of this project will allow for more effective usage of MeerKAT hardware resources and may be beneficial for other large radio-telescope arrays, such as SKA.

Computer Science Content: *data compression; GPGPU computing; algorithm design*

Specific Learning Outcomes: *Design, implement and test algorithms and data structures based on a problem spec.*

Skills Required by Team as a Whole: *Each project component (subsystems for trunk, leaves and bark) requires an initial introductory level understanding of computer graphics and interface design.*

- ***Theory:*** *This project will involve understanding a number of data compression techniques – this maybe be somewhat challenging. Someone with an interest in algorithm design would have a distinct advantage.*
- ***Implementation:*** *The implementation will require coding up some existing schemes and modifying them fit in the MeerKAT data processing pipeline. Familiarity with GPU coding would also be useful. Since the correlator is an FPGA board, someone who has worked on FPGAs would be useful*.

Facilities Needed: *A GPU will be necessary to test and develop the GPU decompressor. Other software/simulators will be decided once the project is accepted. Data will be provided by MeerKAT*

Supervision: *Patrick Marais will serve as principle CS supervisor; a suitable person from the MeerKAT science team will be available for consultations on pipeline issues, FPGA knowledge etc.*

Number of Students: *3*

15. Spatial Navigation of African Cultural Heritage

Proposer: *Hussein Suleman*

Abbreviation: *SNACH*

Brief Description: *The Zamani Project, based at the UCT Geomatics Department, needs an online presentation system for its large spatial data collection of cultural heritage sites. The data comprises of highly detailed 3D models (from 50MB up to 2-5GB per building), photogrammetric and 360 degree panorama imagery, Geographic information Systems (GIS), sections & elevations, plans and videos. The Zamani Project has thus far documented about 40 sites in 12 African countries, with close to 100 3D models of individual structures. The volume of all African Heritage Sites documented so far is estimated to be in the order of 10-20TB!*

There are two major aspects to the problem: storage and presentation. The storage of the data needs to be optimized for easy retrieval via a Web interface, possibly with streaming capabilities due to large files. The presentation and access to the data needs to be designed for interaction, as opposed to a text-based search engine, ideally via an interactive map, similar to Google maps, accommodating the various data types for each heritage site. This is especially necessary for a large collection of images and panoramas.

Optional parts of this project (depending on the number of students) include: presenting large 3D models over the Internet; and using crowdsourcing to improve on the quality of metadata.

The Zamani Project has documented so far about 40 sites in 12 African countries with close to 100 3D models of individual structures.

Computer Science Content: *Digital Libraries, heritage preservation, data storage scalability*

Specific Learning Outcomes: *Research Methodology; Experiment design and execution; Real-world software development*

Skills Required by Team as a Whole: *Each project component (subsystems for trunk, leaves and bark) requires an initial introductory level understanding of computer graphics and interface design.*

- ***Theory:*** *Nothing specific.*
- ***Implementation:*** *Knowledge of XML, HTML, JS and a scripting language – but some can learn "on the job".*
- ***Other:*** *Excitement about the preservation of Cultural Heritage!*

Facilities Needed: *Web Server, Large Data Storage System, Data and Metadata*

Supervision: *Hussein, regular contact with Digital Libraries research group for feedback and assistance, client in UCT Department of Geomatics*

Number of Students: ***2-4***

16. A Knowledge-Base System for Medical Advice Provision

Proposer: *Audrey Mbogho*

Abbreviation: *Advisor*

Brief Description: *In many rural African communities, access to medical advice is extremely limited. People must travel long distances to a clinic, and, once there, there may not be someone qualified to attend to them promptly. This problem can be addressed by installing systems that can give advice for common conditions such as diabetes and hypertension. A lot is known about how to manage these conditions and such knowledge can be cloned and brought closer to the needy through the use of knowledge-based systems. In this project, an existing open source tool, such as CLIPS or JESS will be used to develop a prototype KBS for the provision of medical advice on diabetes or another similarly common condition.*

A second problem affecting rural communities is that of low literacy levels. While some will be able to interact with information systems such as the one described above through text, there are many others who will not be able to do this. The second part for this project, therefore, is to provide a speech-based interface. According to developer.android.com, speech technology can easily be incorporated into apps built using the Android SDK. Hence, an Android device can be used by low-literacy users, while the rest have the option of also interacting through a text-based interface.

Computer Science Content: *Students will need to familiarise themselves with Knowledge-Based Systems (or Expert systems), a subfield of Artificial Intelligence. Human Computer Interaction principles will guide the development of the speech-based user interface and will be used to evaluate it, for example, in terms of how its accuracy and, hence, usability is affected by various accents or noise in the environment.*

Specific Learning Outcomes: *Students will put into practice what they've learnt about system design and development, user interface design and development, and the evaluation of these.*

Skills Required by Team as a Whole: *The system divides naturally into the expert system and the user interface, meaning two people would be ideal.*

- ***Theory:*** *Students will need to develop some understanding of the theory underlying speech to text and text to speech technologies.*
- ***Implementation:*** *The project will involve forms of programming (speech, Android, expert systems) that might be unfamiliar. This is expected to present a moderate challenge.*

Facilities Needed: *An Android device on which to evaluate the finished prototype*

Supervision: *Weekly meetings*

Number of Students: ***2***

17. Crowdsourcing Manuscript Transcription

Proposer: *Hussein Suleman*

Abbreviation: *CROWDS*

Brief Description: *The Citizen Cyberscience Centre is an organization that encourages regular computer users to contribute to large-scale scientific projects, mostly to solve humanitarian problems. This was first achieved by harnessing idle cycles on desktop computers (aka volunteer computing). Most recently, crowdsourcing (aka volunteer thinking) has emerged as a means to exploit human abilities for problems that computers cannot solve easily, such as shape identification in images. This project specifically considers how crowdsourcing can be applied to perform high quality transcription of historical handwritten documents i.e., conversion to machine-readable text.*

PyBossa is an open source platform for crowdsourcing online assistance to perform tasks that require human cognition, knowledge or intelligence (e.g. image classification, transcription, information location etc.). PyBossa was inspired by the BOSSA (http://boinc.berkeley.edu/trac/wiki/BossaIntro) crowdsourcing engine but is written in Python (hence the name!). It can be used for any distributed application, but was initially developed to help scientists and other researchers crowd source human problem-solving skills!

The major parts of this project are to create a reusable library that is integrated with PyBossa to enable the creation of transcription applications; and the application of this library to a collection of data to demonstrate its effectiveness.

For more details, see: http://docs.pybossa.com/ and http://demo.pybossa.com/

Computer Science Content: *Digital Libraries, heritage preservation*

Specific Learning Outcomes: *Research Methodology; Experiment design and execution; Real-world software development.*

Skills Required by Team as a Whole:

- ***Theory:*** *Nothing Specific*
- ***Implementation:*** *Knowledge of XML, HTML, JS and Python – but some can learn "on the job".*
- ***Other:*** *Excitement about the preservation of Cultural Heritage!*

Facilities Needed: *Web server, test data*

Supervision: *Hussein, regular contact with Digital Libraries research group for feedback and assistance, client in Citizen Cyberscience Centre*

Number of Students*:* *2-4*

18. Heritage and Learning

Proposer: *Hussein Suleman*

Abbreviation: *HAL*

Brief Description: *Have you ever seen the much-talked-about Bushman rock art first-hand?*

Archaeological datasets encode and preserve key elements of South African heritage, such as the Bushman rock art. While such collections are an invaluable tool to researchers, they are not generally accessible to the public or anyone outside the tertiary education sector. This project is on the presentation of multiple forms of archaeological data for the express purpose of pre-university learning.

The UCT Department of Archaeology owns multiple datasets of images, laser-scanned caves, GIS data, etc. that will be used to drive the user experience. A user could take a virtual tour through a cave, with annotated, overlaid and hyperlinked data to enhance the experience. The emphasis is on supporting learning through interactive presentation of information.

Major aspects of this project will include the design of the user interface to navigate the data spaces; merging, overlaying and querying multiple datasets; and designing the interaction between users and the data. Experiments with users will confirm the learning aspects of the project.

Finally, given the sensitive nature of the data (where public exposure may endanger heritage sites), security and protections mechanisms are needed to control who sees what.

Computer Science Content: *Digital Libraries, heritage preservation, computer-based learning*

Specific Learning Outcomes: *Research Methodology; Experiment design and execution; Real-world software development.*

Skills Required by Team as a Whole:

- ***Theory:*** *Nothing Specific*
- ***Implementation:*** *Knowledge of XML, HTML, JS and a scripting language – but some can learn "on the job". Some knowledge of graphics and VR is a definite plus.*
- ***Other:*** *Excitement about the preservation of Cultural Heritage!*

Facilities Needed: *Web server, data and metadata*

Supervision: *Hussein, regular contact with Digital Libraries research group for feedback and assistance, client in UCT Department of Archaeology*

Number of Students*: 2-4*

19. Smart Wireless Mesh Networks

Proposer: *Antoine Bagula*

Abbreviation: *SWMN*

Brief Description: *As currently deployed, traditional wireless mesh networks are based on dumb nodes using an omni-directional antenna and a single communication channel to route the traffic offered by their users. Such nodes are unable to implement cognition and take advantage of the emerging white spaces to route the traffic more efficiently in order to provide better Quality of Service(QoS) to the wirelesses network users. Building upon advanced wireless models enabled by the advances in the wireless technology and protocols, this project revisits network management methods previously deployed for wireless mesh routing to asset their implementation in the emerging multi-radio multi-channel mesh networks with a specific focus on cognition both at the level of network nodes also the routing process. The next generation smart mesh networks being studied in this project will consist of smart network nodes that are capable of learning from their environment and broadcast this information to neighbours with the objective of implementing a cognitive routing model where the information learned is piggy-backed on existing mesh routing protocols such as OLSR and BATMAN. The main tasks involved in this project are:*

Task 1*. "Cognitive nodes:" Design of a next generation mesh network including smart nodes that may learn from their environment and broadcast that information to their neighbours in order to allow the mesh network to optimize its routing performance based on informed decision.*

Task 2. *"Cognitive routing:" Design and implement next routing models which include cognition based on the information learned from the nodes environment and either piggy back that information to the existing protocols such as OLSR and BATMAN or implement new protocols such as wireless MPLS.*

Task 3. *"Frequency Management:" Despite its popularity, the Wi-FI protocol used by mesh networks suffers from interference effects resulting from the collocation with different other devices operating in the crowded ISM free frequency band. Using some of the frequencies normally used for Television (TV) broadcast services referred to as "white spaces", the emerging IEEE 802.22 standard for Wireless Regional Area Network (WRAN) provides the potential to overcome the limitations of the Wi-Fi protocol by harnessing cognitive radio (CR) techniques to enable the sharing of the broadcast communication band by allowing data communication to be automatically routed to unused frequencies. Auction mechanisms and other resource sharing techniques will be investigated in this project as a way of sharing the frequency available.*

Starting with a comprehensive survey of the literature on cognitive radio networks, white spaces , spectrum sharing, routing strategies and protocols for wireless mesh networks, this research will look at analytic models for network engineering next generation wireless mesh networks and integrate these models in a frequency market. As part of a bigger project, the results of the simulated networks will be implemented into a heterogeneous network running extensions of the OLSR and BATMAN protocols on PCs, laptops, and ALIX boards.

Computer Science Content: *Wireless Mesh Networking, Network protocols, Cognitive Radio, Resource sharing, Auction mechanisms, Game theory.*

Specific Learning Outcomes: *Protocol design and Implementation, Network Planning, Design and Implementation, Data Mining and Machine learning programming.*

Skills Required by Team as a Whole:

- ***Theory:*** *Network protocols, Cognitive Radio, Resource sharing using auction mechanisms, Situation recognition using machine learning techniques.*
- ***Implementation:*** *strong implementation of a wireless mesh Testbed using Alix Boards will be needed. The testbed will include auction-based resource sharing mechanisms integrated to existing wireless mesh protocols such as OLSR and BATMAN.*

Facilities Needed: *Access to the ISAT MeshTestbed and another Testbed in Sweden*

Supervision: *Regular meetings will be scheduled with the supervisor and members of the ISAT group working on similar projects.*

Number of Students*: 3*

20. Participatory Cloud Computing

Proposer: *Antoine Bagula*

Abbreviation: *PCC*

Brief Description: *It is more and more recognized that while being fast growing, Cloud Computing is a technology that raises issues that need to be addressed to achieve wider adoption. These include 1) the dependence on large Cloud vendors such as Google, Amazon and Microsoft which raise privacy concerns and 2) concerns on the efficiency in Cloud infrastructures which is favoured against resilience. Furthermore, with its data centres growing exponentially, Cloud Computing leads to an ever-increasing carbon footprint that raises environmental concerns. These environmental concerns together with the privacy and efficiency issues need to be addressed through an alternative model for the Cloud conceptualization. Building around the concept of Clouds for the community where networked personal computers are used as computing devices, Community Cloud Computing (C3) addresses some of the issues above by combining Cloud principles with Grid Computing paradigms, Digital Ecosystems principles and Green Computing environmental sustainability.*

Participatory Could Computing (PCC) builds upon Community Cloud Computing principles to support smart networked infrastructures where

- *The computing devices are mostly smart boards which are assumed to be deployed unattended to collect environmental data collected by a network of sensors while allowing emergency messages to be routed by the network of smart boards.*
- *Using an opportunistic resource allocation model, the participatory cloud infrastructure will allow network size growth/decrease by implementing on-demand joining/releasing operations allowing nodes to join the cloud or leave the cloud depending on resource availability, time-of-the-day network use and other parameters which are relevant.*
- *Using an opportunistic data dissemination model, the participatory cloud infrastructure will allow data to be stored/fetched in/from the Cloud and forwarded to processing places using a multi-protocol, multi-devices model in a computing environment where different operating systems may be used by different users on different devices.*

This project aims at investigating the possibility of using smart boards such as the Alix board from PC-Engines in a distributed fashion to form a shared infrastructure providing similar features as a community cloud platform but not strictly adhering to the C3 model and operational constraints of a community cloud platform.

Computer Science Content: *Security, Distributed systems, Machine learning techniques, Sensor networks*

Specific Learning Outcomes: *Embedded systems programming, Protocol design and Implementation, Network Planning, Design and Implementation, Data Mining and Machine learning programming.*

Skills Required by Team as a Whole:

- ***Theory:*** *Statistical analysis methods, Neural networks, Bayesian Belief networks, Artificial Immune Systems, Genetic algorithms, Security protocols and encryption.*
- ***Implementation:*** *Implementation intensive project. Strong implementation of a prototype*

and deployment of a mobile sensor network on Shawco buses will be needed.

Facilities Needed: *Cellphones, Laptops, Gas sensors, Alix boards*

Supervision: *Regular meetings will be scheduled for interaction with the supervisor. Members of the ISAT group working on similar projects will also be involved. Co-supervised by Anne Kayem (Security Aspects)..*

Number of Students*: 3*

21. Internet of Things

Proposer: *Antoine Bagula*

Abbreviation: *IoT*

Brief Description: *The integration of the RFID and Sensor technologies is emerging as an important component of the first mile connectivity of the Internet allowing the information to be accessed not only anywhere and anytime but also using anyone to access any devices. A typical hybrid sensor/RFID networking scenario consists of a proactive monitoring system where a network of RFID tags attached to objects and readers attached to the sensor motes is used as the first mile to a WSN that collects the information on the status of these objects in real-time and conveys this information to a gateway where the information is processed and different services delivered to users based on this information. This may be applied for example in elderly healthcare to control the amount of medicine elderly patients require and assist them in taking the accurate amount of medicine. It can also be deployed in a child localization system to track and locate children within a certain range near some landmarks in the park or similarly in a smart parking system to localize a specific car in a crowed parking. The main tasks involved in this project are:*

Task1. *Supporting QoS in the IoT is a challenge that may be addressed by providing QoS to the multitude of USN islands that form the IoT. We consider in this project a cost-based QoS model where the routing parameters used by IoT protocols such as AODV or Tiny OS beaconing will be adjusted to improve IoTrouting efficiency.*

Task2. *IoT management is another issue that can be addressed by taking advantage of the network monitoring tools provided by traditional IP networks such as Cacti, Warshake, etc. We are considering using the PCC as a Middleware layer of an Internet of the Things (IoT) infrastructure supporting pollution monitoring and mapping in the city of Cape Town.*

Task3. *Security provision is a feature that needs to be integrated in the Internet of the Things. We propose the implementation of a multi-layered security scheme that follows a layered IoT architecture where devices are launched into our daily life to deliver services to different users.*

Computer Science Content: *Network security, Distributed systems, Machine learning techniques, Sensor networks*

Specific Learning Outcomes: *Protocol Implementation, Network Design and Monitoring, Distributed Systems*

Skills Required by Team as a Whole:

- ***Theory:*** *Networking protocol design, IP addressing using Ipv6 and 6LoWPAN, Statistical analysis methods, Neural networks, Bayesian Belief networks, Artificial Immune Systems, Genetic algorithms, Security protocols and encryption.*
- ***Implementation:*** *Implementation intensive project. Modifications to the Cooja and Tossim emulators will be needed. Security mechanisms both at the encryption level and protocol levels will be designed and implemented.*

Facilities Needed: *Z1 sensors and other sensors, Alix boards as gateways.*

Supervision: *Regular meetings will be scheduled for interaction with the supervisor. Members of the ISAT group working on similar projects will also be involved.*

Number of Students*:* *3*

22. Interactive Textbook Authoring Tool (for Python)

Proposer: *Gary Stewart*

Abbreviation: *iTxtBook*

Brief Description: *Currently there are many types of electronic resources for learning programming, or anything else – e.g. videos, text-based tutorials/textbooks, quizzes, online learning environments and electronic marking systems. These are all dispersed and complicate the process of learning. The idea is create a framework for "teachers" and "learners" for authoring and using an interactive textbook for a programming language; integrating text, video, quizzes and electronic marking. The system should have a web-based and tablet application based interface. It is envisaged that the web-based system have user-authentication and have an environment similar to other online learning environment; and the tablet-based system should be able be run offline if technically feasible.*

Web-based systems are accessible on most computing devices. Mobile device are becoming increasingly accessible, particularly in the developing world. Technology is progressively becoming an enabler of learning and education. The trend is also to make educational resources open and accessible. This project is able to make a significant contribution in this regard.

These are some links worth checking out:

www.apple.com/education/ibooks-textbooks

www.moodle.org

*www.**oer**commons.org*

*www.**trypython**.org*

*www.swaroopch.com/notes/**Python***

Computer Science Content: *ICT4D, Computer Science Education, Human Computer Interaction (HCI)*

Specific Learning Outcomes: *mobile development, web development, understanding the education/learning process, meeting particular end-users needs.*

Skills Required by Team as a Whole: *Web Development (HTML, CSS, Javascript, Server Side Scripting (PHP, JSP or Python)), and Mobile Development (Java for Android)*

- ***Theory:*** *Web Development, Mobile Interaction Design*
- ***Implementation:*** *The challenge for the whole system is developing a useable interface for users who may be relatively new to computing. The web-based component will involve mastering complex web technologies. The tablet-based component will involve mastering the usability complexities of mobile interaction design for relatively inexperienced users.*

Facilities Needed: *PCs and Tablets*

Supervision: *Regular meetings with supervisor, approximately every two weeks. Co-supervision with Gary Marsden*

***Number of Students**: 2*