The University of Western Australia
Achieving International Excellence

Engineering, Computing and Mathematics

Centre for Intelligent Information Processing Systems

Annual Report 2008

Contact

Centre for Intelligent Information Processing Systems
Faculty of Engineering, Computing
and Mathematics

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Contents

Director's Report

CIIPS regrouped in 2008 and we would like to welcome our new EECE staff members Jasmine Henry and Chris Croft, as well as our new adjunct members Karen Haines and Kevin Vinsen.

2008 was also our year of the car - or maybe I should say fleet, as we now have three vehicles for various research projects in the group: A BMW X5, donated by BMW for which we would like to express our gratitude, a Hyundai Getz and a Lotus Elise.

While the BMW is being used for research on driver-assistance systems, the Getz and the Lotus have been or will be converted to plug-in electric drive in the REV Project (Renewable Energy Vehicle).

The high school-university interaction project Genesis is thriving and has conducted a number of high school visits around the Perth Metropolitan area and Albany. We are looking forward to including the REV sustainable transport message into future Genesis presentations.

As in previous years, CIIPS has had a steady flow of short- and long-term academic and student visitors in 2008. We are happy to work with them and to continue to strengthen our overseas ties.

Thomas Bräunl

Director
Centre for Intelligent Information Processing Systems

January 2009

Introduction to the Centre

The Centre for Intelligent Information Processing Systems (CIIPS) was established as a "Category A" Centre within the then Department of Electrical and Electronic Engineering at The University of Western Australia in November 1991. Formerly existing as the Digital Signal Processing Research Group within the Department, it has developed into a multidisciplinary research centre which brings together researchers from engineering, science, mathematics and medicine.

The Centre combines an active teaching programme with pure and applied research to provide an environment in which innovative theoretical developments can be rapidly turned into technologies that provide solutions to a range of real-world problems. CIIPS runs the MEICT (Master of Engineering Information and Communications Technology) and the DEICT (Doctor of Engineering Information and Communications Technology) programmes within the School of Electrical, Electronic and Computer Engineering.

The Centre is active in the areas of artificial neural networks, biomedical engineering, control, digital signal processing, image processing, mobile robots, parallel and reconfigurable computing, pattern recognition, software engineering, and automotive systems.

Strong and successful collaboration between the Centre and industry is a key element in its operation. Joint research and development projects with a number of Australian companies have been undertaken, as well as contract research for industry, government and other bodies.

Equipment

The Centre is well equipped for the research that it undertakes. It has a network of running Linux and Windows workstations. Various forms of data acquisition, including speech and image capture, are supported by a variety of peripherals. Sophisticated equipment for the support of hardware design and testing is also available, in particular, software and hardware for the design and programming of field-programmable gate arrays (FPGAs). The Centre also provides about 30 autonomous mobile robot systems in its Mobile Robot Lab.

A number of systems have been developed and constructed for research and teaching purposes, including a reconfigurable parallel computing system using FPGAs and simulation systems for various areas ranging from embedded systems to mobile robot simulation.

The Centre curently has three research cars for various aspects of automotive research:

- BMW X5
- Hyundai Getz
- Lotus Elise S2

Capabilities

The capabilities of the Centre encompass both hardware and software development. Special-purpose devices and circuits can be designed and constructed. Sophisticated software for signal and image processing and pattern recognition can be developed, using adaptive filtering, artificial neural networks and other digital signal processing techniques.

The Centre is well placed to do pure research, applied research, research and development and contract research.

Contact Details

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Members of the Centre

Academic Staff at the School of Electrical, Electronic and Computer Engineering

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Dipl.-Inform., MS, PhD, Habil., SMIEEE, MDHV, MSAE
Robotics; Image Processing; Concurrency; Embedded Systems; Automotive Systems
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Professor Gary Bundell,
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Software Engineering
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Dr Ramachandran Chandrasekhar,
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Meta-Education, Mathematical Software and Human Consciousness
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Mr Chris Croft
BE, MBA, MIEAust, MGMA
Engineering Management; Project Planning
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Dr Jasmine Henry
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Photovoltaics
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Mr Kevin Vinsen
Strategic Planning Systems; Surveillance Systems; Unmanned Vehicles
kvinsen@ee.uwa.edu.au

Professor Terry Woodings,
BSc, DipComp, PhD, FACS, FQSA
Software Engineering, Software Metrics
terry@ee.uwa.edu.au

Professor Anthony Zaknich,
BE, MESc, PhD, BSc, BA, SMIEEE, MAES
Artificial Neural Nets; Signal Processing and Pattern Recognition
tonko@ee.uwa.edu.au

Academic Staff at the School of Mathematics and Statistics

Dr Mike Alder,
BSc(Hons), ARCS, PhD, MEngSc, MIEEE
Artifical Neural Nets; Computer Mediated Education; Pattern Recognition
mike@ee.uwa.edu.au

Academic Staff at WASP (Western Australian Supercomputer Program)

Professor Karen Haines
PhD
Director, Western Australian Supercomputer Program: Supercomputing; Parallel Processing; GPU Programming
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Research Staff

Mr Matt Harley
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Dr Serajul Haque
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Technical Staff

Mr Ivan Neubronner
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Administrative Staff

Ms Linda Barbour
Administrative Assistant; CIIPS Secretary
lindab@ee.uwa.edu.au

Visitors

Mr Johannes Brand
Technische Universität, München, Germany

Mr Torsten Sommer
Technische Universität, München, Germany

Dr Ji Xiang
Zhejiang University, Hangzhou, China

Mr Thomas Rückstiess
Technische Universität, München, Germany

Mr Markus Dittmar
FH Giessen Friedberg, Germany

Mr Benedikt Dietrich
Technische Universität, München, Germany

Mr Martin Geier
Technische Universität, München, Germany

Mr Lim Cheng Siong
Universiti Teknologi Malaysia

CIIPS Labs

Automotive Lab

Prof. T. Bräunl
REV (Renewable Energy Vehicle)
Location: EECE G.50

High Integrity Computer Systems Lab

Prof. G. Bundell, Prof. T. Woodings
High-performance, high-reliability and high-quality computer hardware and software systems design methodologies and management
Location: EECE 3.02

Integrated Sensory Intelligent Systems Lab

Prof. A. Zaknich
Adaptive Self-Learning Systems, Intelligent Signal Processing, Audio and Underwater Applications
Location: EECE 3.11

Photovoltaic Lab

Dr. J. Henry
Photovoltaic Devices and Systems
Location: EECE 1.67

Robotics and Automation Lab

Prof. T. Bräunl
Intelligent Mobile Robots, Embedded Systems, Image Processing, Automotive Systems, Simulation
Location: EECE 3.13

Systems Engineering Analysis Management Lab

Mr. C. Croft
Applied Engineering Projects, Project Planning and Management
Location: EECE 4.26

Students

Postgraduate Students

Doctor of Philosophy

Ms Saufiah Abdul Rahim
Multi-Robot Scenarios (T.Bräunl)

Mr Adrian Boeing
Genetic Algorithms (T.Bräunl)

Mr Dariush Farrokhi
Speech Enhancement of Non-Stationary Noises (R.Togneri/A.Zaknich)

Mr Serajul Haque
Perceptual Features for Speech Recognition (R.Togneri/A.Zaknich)

Mr Chang Su Lee
A Framework for Adaptive Fuzzy Systems (T.Bräunl/A.Zaknich)

Mr James Ng
Path Planning (T.Bräunl)

Mr Soo Siang Teoh
Development of robust vision-based vehicle detection and tracking algorithms for driver assistance application (T. Bräunl)

Mr Azman Muhamed Yusof
Vision Tracking (T.Bräunl)

Mr Weiqun Zheng
Model-Based Software Component Testing (G.Bundell)

Doctor of Engineering (ICT)

Ms Sujatha Bulandran
Communicating Assumptions during the Requirements Engineering Process in Multi-site Organizations (T.Woodings)

Master of Engineering (Research)

Mr Yves Hwang
Automatic design synthesis framework in practice: an examination and evaluation (G. Bundell)

Master of Engineering (ICT)

Mr Tejas Upendra Bokare
(K. Haines/T. Bräunl)

Ms Neha Dike
(T. Bräunl)

Ms Rupali Ganguly
(K. Haines/T. Bräunl)

Ms Suet May Khong
(T. Woodings)

Mr Phillip O'Neill
(A. Zaknich)

Mr Pal Simen Ruud
(T. Bräunl)

Mr Chumith Chandana Ukwattage Don Suriwardana
(T. Woodings)

Mr Adrish Guha Thakurta
(T. Woodings)

Shi Wang
(G. Bundell)

Mr Mohammad Zanjani
(T. Bräunl)

Postgraduate Degrees Completed

Doctor of Philosophy

Mr Serajul Haque
Perceptual Features for Speech Recognition (R.Togneri/A.Zaknich)

Mr Peyman Kouchakpour
Population Variation in Canonical Treebased Genetic Programming (A. Zaknich/T. Bräunl)

Master of Engineering (ICT)

Mr Pal Simen Ruud
Evaluation of a Vision based Driver Assistance System in Simulation (T. Bräunl)

Mr Edwin Soebijono
An Examination of the Applicability of the Work Transformation Model to the Software Process (T. Woodings)

Mr Chumith Chandana Ukwattage Don Suriwardana
Integration of PSP and TSP into Agile Methods (T.Woodings)

Undergraduate Students

Final Year UWA

Blair Anthony Bartley
Steven Bradley
William James Chin
David Nelson Allan Churn
Karl Thomas Daws
Andrew Ross De Gruchy
Michael Eastwood
Steve Ip
Surendran Vijay Kumar
Shu Shan (Johnny) Lee
Winston Ma
Ewan MacLeod
Rohan Mani Mathew
Alexander Meegan
Dale Steven Morey
Kelly Naunton
Michelle Ovens
Tim Pyper
Blake Duncan Samuels
Evgeni Sergeev
Amar Shah
Dyizen Tan
Justin Ward
Jocelyn Williams
Steven Whiteley

International Exchange Students: University of Notre Dame, U.S.A.

Elizabeth Ruhl
Jeffrey Henkel
Aron O'Connor
Arthur Kinsey
Rob Jones
Britney Dudley
Kelsey Kennedy
Nicole Artman
Carl Beyer

Group Photo

Staff, students and visitors of CIIPS 2008.

Back row, left to right: Michelle Ovens, Evgeni Sergeev, Ivan Neubronner, Martin Geier, Markus Dittmar, Chang Su Lee

2nd row, left to right: Neha Dike, Adrish Thakurta, Elizabeth Ruhl, Arthur Kinsey, Benedikt Dietrich, James Ng, Weiqun Zheng, Soo Siang Teoh, Linda Barbour

Front row, left to right: Amar Shah, Ewan MacLeod, Stephen Whitely, Rohan Mathew, Aron O'Connor, Budianto Budianto, Serajul Haque

Research Activities

Automotive Lab

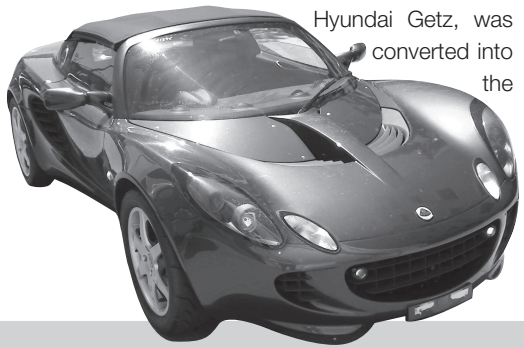
Professor T. Bräunl

The Automotive Lab was established in 2008 and is dedicated to the research on driving economy, such as plug-in electric vehicles, as well as active driving safety using driver-assistance systems.

The Automotive Lab currently houses three vehicles, a BMW X5, a Hyundai Getz and a Lotus Elise S2. The Engineering Faculty's REV Project (Renewable Energy Vehicle) is part of this lab. Details can be found at:

http://robotics.ee.uwa.edu.au/automotive.html
and http://theREVproject.com

The REV Project (Renewable Energy Vehicle) immediately drew the largest number of students ever in a student project in the School of Electrical, Electronic and Computer Engineering. In the REV project, 28 students from different Engineering backgrounds (Mechanical, Mechatronics, Electrical, Computer, Software) worked on the electric conversion of a standard 5-seater, 5-door commuter vehicle. The base vehicle, a Hyundai Getz, was converted into the REV ECO and subsequently re-licensed for road worthiness by the DPI. Although using mostly existing technologies, this was a major undertaking. The actual electric driver conversion using 144V Lithium-Ion batteries with a gear-box-mounted DC electric motor was only about half the effort. A number of smaller projects had to be completed to ensure the road-worthiness of the car: electric power steering, electric vacuum brake assist, electric heating, electric air-conditioning. Also, an innovative in-car embedded computer control and instrumentation system has been developed, based on the Robotics and Automation Lab's EyeBot M6 embedded controller.



Two further projects have just been started, but will mainly fall into 2009 for completion: The conversion of the BMW X5 to drive-by-wire, in order to use it as a test vehicle for our driver-assistance systems, and the plug-in electric conversion of the Lotus Elise.

High Integrity Computer Systems Lab

Professor G. Bundell, Professor T. Woodings (formerly known as the Information and Software Engineering Research Group)

The name of the Group was changed at the start of 2008 to reflect the refocussing of research effort and reorganisation into a Laboratory.

The aim of the Laboratory is to engage in research into the engineering of high-integrity information and software systems. Such research requires the development of tools and methodologies to aid the design of these systems; performance analysis, measurement and benchmarking of these systems; and evaluation of the organizational and environmental context in which these systems need to operate. As such, it is very much a multi-disciplinary endeavour that requires an understanding of the underlying information and communications technology, robust engineering design principles and practices, and extensive knowledge of current and potential applications for these types of system.

The main contract research conducted has been in safety critical embedded systems for the resources industry, specifically in an automatic train control application for MRX Technologies. This has involved research into embedded systems development to the IEC 62278/6227 9 standards, and development of specific software subsystems for the on-board equipment replacing the train driver.

Postgraduate research (MEngSc) in automated software generation from UML specifications was completed this year and is in examination, and work linking component design information to earlier work on software component testing has further progressed (via a PhD) and is expected to be completed in 2009.

Another important thread of research, undertaken in the software engineering area, is concerned with software project and process metrics. This includes studies on the requirements engineering of systems with the allocation of priorities, when there are insufficient resources, based on the measurement of value and effort. Project risk is being studied with reference to assumptions made in the requirements definition process. Work is continuing on techniques for systematic process improvement based on a reduction in variation in the estimation of relevant project parameters. Postgraduate research (DEICT) in this area has been focussed on assumptions analysis and this was further advanced this year.

Integrated Sensory Intelligent Systems Lab

Professor A. Zaknich

The Lab's activities are related to the philosophy, theory and applications of intelligent signal processing, including; learning theory; self-learning systems; artificial neural networks; adaptive systems; time-frequency filters and signal analysis; time delay spectrometry; adaptive space-time frequency signal processing; audio and Hi-Fi; and underwater acoustic communications.

Two PhD students completed their theses and graduated in 2008: "Population Variation in Canonic Treebased Genetic Programming" by P. Kouchakpour and "Perceptual Features for Speech Recognition" by S. Haque. Dr Kouchapour has published three journal papers during the course of his studies, while Dr Haque has published one journal and two international conference papers. Another PhD student has submitted his thesis for examination: "A Framework of Adaptive T-S type Rough-Fuzzy Inference Systems" by C. S. Lee. P. O'Neill has started working on a "Commercial in Confidence" Masters project on video compression algorithm analysis and a hardware prototype design.

A number of audio DSP projects are in progress leading towards the development methods of accurate measurement of loudspeaker responses in non-anechoic environments, 3-D loudspeaker frequency response models and efficient loudspeaker equalisation filters. This work is the basis of a new book in progress, "Loudspeaker response testing, modelling and equalization: Including a complete design and testing project example". There are very few published books on this topic so it will fill a hole in the market by providing a valuable research and application resource on the topic.

Meta-Education, Mathematical Software and Human Consciousness

Dr R. Chandrasekhar

The focus of work in 2008 was on aspects of education: mathematics, "how to study", and exploring study techniques that will improve student learning and retention.

Work continued on the series of mathematics books to assist students making the transition from high school to the first two years of university. The first volume, entitled "Numbers" is one-third complete. A companion website is also being designed for these books. It will feature software for a mathematics laboratory that can be run on PCs and laptops for self-study by interested students of mathematics. It is anticipated that the platform-neutral SAGE open source mathematics software package, written in Python, will provide the foundation for this laboratory. The software laboratory will emphasize discovery, concreteness, sensory richness, and rigour. For example, two simple programs for this laboratory are demonstrations of the Sieve of Eratosthenes, and of

Buffon's Needle. Such demonstrations will allow the student to follow the time-evolution of these mathematical algorithms. Two final-year project students are expected to work on developing programs for the mathematics laboratory in 2009.

There was also progress on the generic "how to study" book addressed to students: from high school, through undergraduate, to post-graduate. It is a practical manual that addresses many fundamentals that are not covered in conventional school and university curricula. For example, techniques are presented for reading a textbook chapter, and for reading a journal paper, including what is done the same, and what is done differently. Other areas like memory skills, and techniques for their development, are also considered. Two mature chapters and one draft chapter have been made available from

http://www.ee.uwa.edu.au/~chandra/

The third area of activity, research into consciousness, is in an inchoate stage. The current focus is on transitional states like hypnagogia and lucid dreaming: their mathematical modelling and their usefulness toward student learning and retention. Given the subjective nature of this area, most experiments have thus far been reflexive and exploratory.

Photovoltaic Lab

Dr J. Henry

Position Sensitive Detectors:

This programme was started in 1999 and has been the main focus of the group's efforts. PSDs are an important class of optical sensor which produce an electrical output, either voltage or current, in response to an impinging spot of light. These devices utilise the lateral photovoltaic effect to give a linear relation between the output and the location of a spot of light directed on to a semiconductor surface. Devices have been fabricated from crystalline and from amorphous silicon, in a Schottky barrier configuration. Other research groups in the area use complex multi-layered structures fabricated using chemical vapour deposition methods while we have used sputtered and electron beam systems to fabricate our devices. This has been devised to avoid toxic gas systems and inherently complex deposition procedures. This work has been quoted in a variety of publications, including citations by overseas leaders in the area.

Solar Cells:

The published work in this area is based on Schottky barrier structures which are a type of metal-semiconductor interface which performs well compared to more complex structures. This has been a secondary aspect of our research and projects and work in this area are mainly undertaken by final year project students, although it has received financial support from the Minerals and Energy Research Institute of WA. In 2009 work is being restarted in this area and thin film layered structures developed from inexpensive and simple but reproducable techniques will be utilised.

Robotics and Automation Lab

Professor T. Bräunl

The Robotics and Automation Lab was established in 1998 and is dedicated to the research on intelligent autonomous mobile systems.

Using embedded systems, over 30 mobile robots have been designed in the lab, while the development of simulation systems also plays a major role in the lab's research efforts.

Details can be found at:

http://robotics.ee.uwa.edu.au

A new compact mobile robot has been developed around our new EyeBot M6 embedded system. This is now running at 400MHz on an ARM-9 CPU with an integrated Xilinx FPGA for image pre-processing. The robot is equipped with digital stereo cameras, three infra-red distance sensors, host-USB, LAN, Bluetooth and a color touch screen.

Current implementation work concentrates on moving low-level image processing functions from the CPU into the FPGA to free the CPU for higher level processing tasks and therefore increase throughput and overall image processing speed.

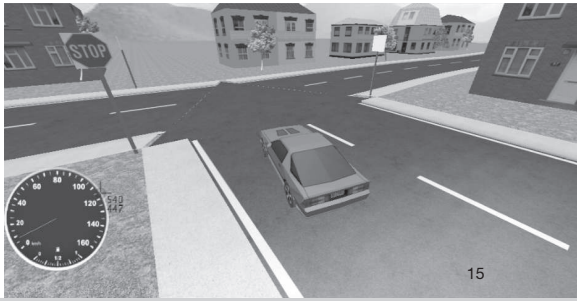
The AutoSim automotive simulator is a larger scale project which will allow us to implement, test, and evaluate our driver-assistance systems in software before they are actually being built in hardware. For this we are coupling an immersive driving simulator with full 3D physics simulation and video feedback to our vision-based driver-assistance systems. This project will evolve over the next years and will see the implementation of a car simulator built around a complete car chassis with three surrounding walls. On the modelling side, we plan to generate typical city scenes from Australia (Perth/Crawley), North America (Los Angeles), and Europe (München).

The Genesis high school interaction project has been extended with a number of new experiments, mostly based on Microchip's Basic-programmable PICAXE microcontroller. A partnership has been established between UWA's Genesis and Murdoch-based ASISTM project (Australian Schools Innovation in Science, Technology and Mathematics), which hopefully will allow us to reach even more high schools. Interested high schools can contact us from the Genesis web site and arrange for a school visit by our Genesis demonstrators or order teaching material and PCBs free of charge.

http://genesis.ee.uwa.edu.au/

In 2008 the Robotic and Automation Lab hosted the following visitors:

Johannes Brand.TU, München, Germany
Torsten Sommer, TU, München, Germany
Ji Xiang, Zhejiang University, China
Thomas Rückstiess, TU München, Germany
Markus Dittmar, FH Giessen, Germany
Benedikt Dietrich, TU München, Germany
Martin Geier, TU München, Germany
Lim Siong, UTM, Malaysia



Publications 2008

Book

Bräunl, T.
Embedded Robotics - Mobile Robot Design and Applications with Embedded Systems
Third Edition, Springer-Verlag, Heidelberg Berlin, 2008, pp. (XIV, 541)

Book Chapter

Henry, J., Bundell, G.A. and Togneri, R.
Strategies for attracting undergraduate students into an electrical engineering programme
iNEER (International Network for Engineering Education and Research) Special Volume INNOVATIONS 2008, Chapter 31. World Innovations in Engineering Education and Research.

Zheng, W. and Bundell, G.A.
A Framework of UML-Based Software Component Testing
In Oscar Castillo, Li Xu and Sio-long Ao (Eds.), Current Trends in Intelligent Systems and Computer Engineering, Lecture Notes in Electrical Engineering, Vol. 6, Springer, May 2008.

Conference Papers

Boeing, A. and Bräunl, T.
ImprovCV: Open Component Based Automotive Vision
IEEE Intelligent Vehicles Symposium, IV, June 2008, Eindhoven, Netherlands, pp. (6)

Bulandran, S.
How Vulnerable are Specifications to Assumptions?
The Symposium on Software Requirements Engineering, Engineers Australia WA Division, 1 August 2008, Perth, Western Australia

Farrokhi, D., Togneri, R, and Zaknich, A.,
Single channel speech enhancement using a 9-dimensional noise estimation algorithm and controlled forward march averaging
9th IEEE International Conference on Signal Processing (ICSP'08), 26–28th October 2008, Beijing, China

Henry, J.
Engaging non-EE major engineering students in a foundational EE unit
INTED 2008, International Association for Technology, Education and Development (IATED), 3–5 March 2008, Valencia, Spain

Henry, J. and Livingston, J.
High sensitivity optical position sensitive detectors fabricated from high resistivity substrates
In Optical Sensors 2008, Edited by F. Berghmans, et al, Proceedings SPIE Vol 7003. Presented at Photonics Europe 2008 International Symposium, 7–10 April 2008, Strasbourg, France

Lee, C. S., Zaknich, A., and Bräunl, T.
A framework of adaptive T-S type rough-fuzzy inference systems (ARFIS)
IEEE International Conference on Fuzzy Systems (FUZZ-IEEE2008), June 2008, Hong Kong, China, pp. 567-574

Woodings, T. and Roy, G.
Progress in Software Requirements Engineering
The Symposium on Software Requirements Engineering, Engineers Australia WA Division, 1 August 2008, Perth, Western Australia

Woodings, T. L.
Software Requirements Engineering – An Introduction to some Major Problems
Presented at Symposium on Software Requirements Engineering, Engineers Australia WA Division, 1 August 2008, Perth, Western Australia

Woodings, T. L.
Writing Safety Critical Software
Paper delivered to the Software Engineering Forum, Engineers Australia, November 2008, Perth, Western Australia

Zheng, W. and Bundell, G.A.
Test by Contract for UML-Based Software Component Testing,
The 2008 International Symposium on Computer Science and its Applications (CSA–08), 13–15 October 2008, Wrestpoint Hotel, Hobart, Australia

Journal Articles

Haque, S., Togneri, R., and Zaknich, A.
Perceptual features for automatic speech recognition in noisy environments
Speech Communications, Elsevier, Vol. 51, No. 1, pp. 58-75, January 2009.

Henry, J. and Livingston, J.
Improved position sensitive detectors using high resistivity substrates
Journal of Physics D: Applied Physics. 41 (2008) 165106

Kouchakpour, P., Zaknich, A., and Bräunl, T.
Dynamic population variation in genetic programming
Information Sciences, 2008. (Accepted for Publication 17-12-08)

Kouchakpour, P., Zaknich, A., and Bräunl, T.
A Survey and Taxonomy of Performance Improvement of Canonical Genetic Programming
Knowledge and Information Systems, 2008, December 2008

Invited Conference Keynote Presentations

Bundell, G.A.
The Engineering of Information Architecture
WICOM: Engineering, Services and Knowledge Management 2008, 15–17 October, Dalian, China

Conference Chairs and Programme Committees

Bräunl, T.

- IEEE Computer Society's Technical Committee on Parallel Processing, Member.
- IEEE Robotics and Automation Society's Technical Committee on Marine Robotics, Member.
- Robot Vision , 18-20 Feb, Auckland, New Zealand.
- IEEE International Conferences on Robotics, Automation & Mechatronics (RAM 2008), 3-6 June, Chengdu, China.
- NTMS'2008 Workshop on Wireless Sensor Networks, 5-7 Nov., Tangier, Morocco.
- Australasian Joint Conference on Artificial Intelligence (AI-08), 1-5 Dec, Auckland, New Zealand.

Woodings, T.

- Chairman ITEE College (WA) one day symposium Engineers Australia 1 August 2008, Perth.

Vinsen, K.

- Industry co-chair for ASWEC 2008 (Australian Software Engineering Conference), 25–28 March, Perth, Western Australia.
- Reviewer 22nd IEEE-CS Conference on Software Engineering Education and Training, 17–19 February 2009, Hyderabad, India.

Journal Editorial Boards/Advisory Boards

Bräunl, T.

- International Journal of Social Robotics (Springer-Verlag), Associate Editor and Member of the Editorial Board.
- International Journal of Advanced Robotic Systems, Editorial Advisory Board Member.
- International Journal of Simulation Modelling, Editorial Board Member.

Research Grants/ Contracts

Bundell, G.A.
Development of a Robust Design and Testing Approach for an Embedded Mission Critical Supervisory Train Controller Algorithm,
MRX Technologies, $130,000

Henry, J.
Solar Homes and Communities,
Photovoltaic Rebate Scheme, $9142

Peyman Kouchakpour

Supervisors: Anthony Zaknich/ Thomas Bräunl

Population Variation in Canonical Tree-based Genetic Programming

The Genetic Programming paradigm, which applies the Darwinian principle of evolution to hierarchical computer programs, has produced promising breakthroughs in various scientific and engineering applications. However, one of the main drawbacks of Genetic Programming has been the often large amount of computational effort required to solve complex problems. There have been various amounts of research conducted to devise innovative methods to improve the efficiency of Genetic Programming. This thesis has three main contributions. It firstly provides a comprehensive overview of the related work to improve the performance of Genetic Programming and classifies these various proposed approaches into categories. Secondly, a new static population variation scheme (PV) is proposed, whereby the size of the population is varied according to a predetermined schedule during the execution of the Genetic Programming system with the aim of reducing the computational effort with respect to that of Standard Genetic Programming. Within this new static scheme the initial population size is made to be different from the initial size of the Standard Genetic Programming such that the worst case computational effort is never greater than that of the Standard Genetic Programming. Various static schemes for altering population size under this proposal are investigated using a comprehensive range of standard problems to determine whether the nature of the "population variation", i.e. the way the population is varied during the search, has any significant impact on Genetic Programming performance. It is shown that these population variation schemes do have the capacity to provide solutions at a lower computational cost compared with the Standard Genetic Programming. Thirdly, three innovations for dynamically varying the population size during the run of the Genetic Programming system are proposed. These are related to what is called Dynamic Population Variation (DPV), where the size of the population is dynamically varied using a heuristic feedback mechanism during the execution of the Genetic Programming with the aim of reducing the computational effort. The efficacy of these innovations is examined using the same comprehensive range of standard representative problems. It is shown that these new ideas do have the capacity to provide solutions at a lower computational cost compared with standard genetic programming and previously reported algorithms. Finally, further interesting research potentials for population variation are identified together with some of the open areas of research within the Genetic Programming and also possible future trends in this discipline.

Mr Pal Simen Ruud

Supervisor: Thomas Bräunl

Evaluation of a Vision based Driver Assistance System in Simulation

Testing driver assistance systems on real vehicles in real environments is both costly and dangerous. By developing an automotive simulation system, new driver assistance systems for vehicles can be tested and improved in a safe and reliable way. The work of this project has assisted in the development of the automotive simulation system AutoSim and further integration of the image processing framework ImprovCV in order to be used for autonomous driving of vehicles in AutoSim. For the development of AutoSim, contributions have been in the area of content creation, 3D modelling and physics simulations. Finally, lane detection based on image processing in ImprovCV was used in order to demonstrate autonomous driving and a driver assistance system in AutoSim. Two different scenarios were created for the experiments and different controllers were used in order to find the most robust one. Implementation of the Fuzzy logic controller proved to be the most suitable one when looking at the overall performance for the two scenarios.

Also as different physics engines are known to behave differently, the experiments were conducted using two different ones, Bullet and Newton, in order to further verify the robustness of the autonomous driving. Differences in the physics engines were discovered and only the Fuzzy logic controller implementation completed all scenarios with both physics engines.

Mr Edwin Soebijono

Supervisor: Terry Woodings

An Examination of the Applicability of the Work Transformation Model to the Software Process

This thesis proposes the application of an existing generic approach, the Work Transformation Model (WTM), to the measurement of the Total Process Time (TPT) of a software process. The measurement can be used to analyse the impact of changes on the process to the overall time it takes to complete, and therefore to allow the project manager and the team to make rational decisions about implementing such changes.

The application of this model provides a simulated outcome of a process change that can be used to verify the effects of the change before the actual implementation, ensuring that undesirable or costly consequences are avoided. The measurement of the impact of a change is given as a ratio of the TPT without implementing the change against the TPT after implementing the change. This measurement is termed the Simulated to-be/as-is Ratio (STAR).

The model was adapted to the software development domain. An analysis of the assumptions and constraints of the current model was made, and modifications were carried out on the model to achieve suitable application for software processes. The criteria for process convergence in the model were also reviewed. The process in the model is defined to have converged when the amount of work transformation shows little variation between consecutive iterations.

Mr Chumith Chandana Ukwattage Don Siriwardana

Supervisor: Terry Woodings

Improvements in Software Project Control Based on Alternative Processes, with Examples from Industry

Complex requirements, high customer expectations and volatile environments cause software projects to be inherently complex. Failure to identify these complexities has precipitated a legacy of poor project management in the software industry.

Complex projects demand careful planning with rigid processes in place. A well-defined process manages specifications, construction, validation and evolution of a software product. It makes sure that vital resources are directed in a productive manner with respect to budget limits, schedule and quality. An efficient process should be dynamic and needs to be tailored for specific organisations, project environments, and market contexts.

This research investigates the project controls introduced by different software processes. It looks into reasons for a process, features and the evolution of different methodologies. Furthermore it evaluates the strengths of the Scrum approach by analysing its introduction to a software organisation. Rapid recent growth, schedule issues and budget overflows warranted a new process for this organisation. Further the process needed to be tailor-made for their highly specialised application context. In the evaluation process, the author was fortunate enough to get actual data from the organisation for a large project developed under the newly introduced processes. Using estimation and resource allocation data for selected iteration tasks, the controllability, flexibility and effectiveness of this alternative process was evaluated.

There have been few ‘industrial-strength’ assessments of such Agile processes as Scrum and this research provides data and insights into their advantages and disadvantages.

Abstracts of Final Year Project Dissertations

Blair Anthony Bartley

Supervisor: Jasmine Henry

The Application of Solar Technology to Power Remote Mining Sites

Mining has a long history and techniques have been perfected over time to provide the safest environment for workers. As a result of this, innovation is not normally a part of the mining mindset with most people adhering to well known techniques and methods. One of the areas this is particularly true is with electricity generation. The usual method for electricity generation on remote sites is to use diesel generators which are relatively cheap in terms of fuel and capital infrastructure. However, there may be better ways which can protect the environment, capital expenditure, maintenance and safety. The ultimate goal of this project is to achieve a sustainable way of generating power without discomforting the workers, or affecting the output of the mine.

The Pilbara has some of the best sunlight in the world so solar power is the primary choice of electrical production. Sunlight consists of both optical and thermal energy, both of which can be harnessed to provide energy through either the use of photovoltaic cells or thermal concentrators.

As solar power is expensive compared to traditional power generation methods, reducing electrical load demand will both save money and reduce carbon emissions. Electrical efficiency is also important as it means extra energy is available while reducing the need to generate that energy. To do this and increase the comfort of the workers, a new type of accommodation units will be looked at.

Due to the nature of this project and the collaboration with Rio Tinto Iron Ore (RTIO), there is a need for confidentiality for some items. In this paper, these items will be marked as having been changed to protect RTIO confidentiality, but the method used to obtain these results will be the same. The only difference will be that some of the numbers and figures that are used will be changed.

David Churn

Supervisor: Thomas Bräunl

RoBIOS Routines for the Eyebot M6

The Eyebot M6 is an innovative new mobile robotics platform currently being developed in the school of Electrical Engineering. Powered by a 400MHz Intel X-Scale processor and SPARTAN 3E Field Programmable Gate Array, the M6 is designed to replace the existing Eyebot modules which have been used for many years with much success. Boasting twin colour cameras capable of stereovision, a 4.3" colour touchscreen and a vast array of customisable sensors and actuators, the Eyebot platform will be used as a controller for future Robotic projects at UWA, as well as a practical laboratory tool for future Engineering students.

With construction of the Eyebot M6 beginning in 2006, the platform is an ongoing project carrying over several theses, with each student providing additional functionality to the Eyebot. This thesis focusses on the hardware drivers for several sensors and actuators of the Eyebot, including the motors, wheel encoders, infra red distance sensors and digital IO. This thesis also includes the addition of user-defined configuration files to the Eyebot. Finally, a testing program, which can be run from the touchscreen of the Eyebot M6, lists the hardware attached to the M6 and displays current calibration settings, as well as providing a simple demonstration to test each device.

Karl Thomas Daws

Supervisor: Thomas Bräunl

Autonomous Control of an Underwater Vehicle

Autonomous Underwater Vehicles (AUVs) are an area of robotics which is becoming more widespread in industry. It is hazardous to send humans deep underwater for long periods of time and communication underwater is difficult. An AUV does not require a human pilot; instead it employs a range of sensors to gather data and then make its own decisions with high and low level controllers. Industrial applications include exploration/maintenance for oil and gas industries, underwater mapping and observing marine life.

Project Mako is an AUV that was designed and constructed in 2004 at UWA. The Mako project was designed for research and competition use and hence has four main tasks which mimic commercial applications. Currently, some systems are being replaced or repaired in order for Mako to function and achieve these tasks. Image processing, localisation and autonomous control are required for the AUV to operate effectively. This requires complex modelling, reading multiple sensors and then controlling motor outputs. Wall following and heading control have been experimented with and the results analysed.

Michael Eastwood

Supervisor: Jasmine Henry

Renewable Energy System for the IDEAL House

Sustainability is a key term in modern engineering. To engineer in a sustainable way means more than recognizing and following the politically-correct edicts of the environmental lobby. In the field of energy production in particular, sustainable engineering is the vehicle through which civilisation continues to operate in a world of depleted fossil fuels. The IDEAL House is a demonstration of those sustainable technologies that must not be considered ‘future’, but are available for implementation immediately. A zero-emission renewable energy supply is one way in which the House demonstrates sustainability through responsible energy production.

This report presents a survey of various renewable energy technologies available for implementation. Selecting a solar photovoltaic system from those options, the author examines the solar energy resource available at the IDEAL House, principles of and options for solar energy production and the series of

existing Australian Standards that provide guidance for the implementation of solar photovoltaic power supplies. The author uses the results of these investigations to design a solar power system suited to the IDEAL House and cognizant of its particular needs as a transportable accommodation unit and its use as an educational facility. With the aid of federal funding and the School of Engineering Computing and Mathematics, the author undertook to construct, install and commission the designed system.

Two months after installation the solar energy system has produced more than 60% of the energy consumed by the House since the inception of the project. Excess energy is injected into the university's local grid, reducing the energy footprint of surrounding buildings. The solar system is capable of folding down for transport and tilting to follow seasonal variations in the height of the sun above the horizon. It is capable of extending out over the edge of the roof of the House, providing shade to its north-facing windows during summer. Its capacity for shading reduces heat gained by the House on hot days, reducing the need for air-conditioning and improving energy efficiency - a key goal for economic sustainability in a future of higher energy costs.

The solar array also serves as a platform for future development in control systems and energy studies. It has the potential to be a means of tangible support for teachers ushering in the new energy future through the education of young engineers.

Chun Shing Ip

Supervisors: Kamy Cheng/Thomas Bräunl

Battery Restraint System Design and Performance Evaluation for Renewable Energy Vehicle Project

In Australia, the current transport energy use is extremely inefficient due to heavy dependence on personal transport systems. Although public transport is available, it is considered slow and impractical compared with personal transport. To combat these issues, the Renewable Energy Vehicle of the University of Western Australia is created in effort to rises the awareness of renewable energy within the University and wider community. In this project, the battery restraint system must be designed and built by considering the constraints imposed and adhering to the relevant codes and regulations. To achieve these, the prototype of the potential design was created with the aid of SolidWorks and subsequently analysis under specific condition was conducted through the use of ANSYS Workbench.

This project also evaluated the propulsion power requirement by determining the resisting forces acting on the vehicle. Nevertheless investigation into the effect of variations in ride height and weight distribution on the handling behaviour was performed using a standard vehicle as datum. The procedures established in this study will provide a basis for future battery restraint system design, as well as future performance evaluation.

Surendran Vijay Kumar

Supervisor: Terry Woodings

Measuring the Relative Productivity of Programming Languages

Software Metrics has long been a topic of debate in the industry of software development. Software metrics is defined as a measure or quantification of quality, efficiency, size and other attributes as well as cost and effort taken for the completion of a software project. Even with the evolution of more sophisticated approaches to software development such as object-oriented programming (OOP) and languages such as Java, C# and Ada 2005, significant difficulty still arises in measuring software productivity and knowledge in a software system accurately.

This thesis considers the impact of different programming languages in the development of a software project or system; attempts to empirically measure the productivity of different software languages that affect the development time of a project or system; and attempts to present and study the variation of knowledge levels in a system that uses various programming languages and represent these data statistically.

Empirical experiments were conducted pertaining to certain constraints and methodology that were outlined beforehand. The problem domain that was to be addressed in this thesis was critically analysed to provide useful informative insights in the area of our research. A number of participants were involved in the experiment process to reiterate or displace hypotheses that were drawn prior to the experiment and based on the reality of developing a software project.

The results of the experiments were critically analysed to draw suitable conclusions in the topic of software metrics. The results obtained provide new insights into this subject and should be taken into consideration for further research and development in using empirical procedures in the measurement of software productivity and knowledge of a software system.

Winston Ma

Supervisors: Kamy Cheng/Thomas Bräunl

Renewable Energy Vehicle (REV) - Mechanical Design and Constructions Tasks

With the increase of environmental issues, energy consumption, greenhouse gas emissions and limited fossil fuels, investigation into clean and renewable energy becomes necessary for future development. The objective of REV project is finding a renewable and non-pollution energy for future transportation which can alter the usage of fossil fuels. To convert the existing Getz, mechanical design and construction tasks include design motor mounting support system, battery cage, coupling, and also include investigations into suspension system, load distribution and aerodynamic performance. In this thesis, background information for all these mechan-

ical design and construction tasks is given in a literature survey. A group report focusses on design processes and results analysis of motor mounting support system and coupling, designed components, materials selection, choice of manufacturing technologies and construction processes. A basic risk management for these mechanical design and construction tasks are also analysed and presented. The design and construct of motor mounting support and coupling contribute 70% of the overall mechanical works of REV in 2008. The vehicle will be completed by the end of 2008 and further investigation will be focused on road testing performance.

Ewan MacLeod

Supervisor: Thomas Bräunl

Eyebot M6 Controlled Sensor Package in a Renewable Energy Vehicle Hyundai Getz

The EyeBot M6 is an innovative new mobile robotics platform currently being developed at the University of Western Australia. Powered by a 400MHz ARM9 processor and SPARTAN 3E Field Programmable Gate Array, the EyeBot has a vast array of customisable sensor inputs and actuator outputs, a colour touch screen, and peripheral access to rival a computer.

The Renewable Energy Vehicle project hopes to revolutionise personal transport by building vehicles that produce no pollution, powered by a renewable energy source. The project is currently tasked with converting a five-door petrol Hyundai Getz into an electric car, by replacing existing components with batteries, an electric motor, and new instrumentation and sensors.

The EyeBot M6 construction and REV conversion projects are ongoing projects covered over several theses, with each student contributing to the development of the EyeBot or vehicle. This thesis focuses on the design and development of a Black Box data recorder and sensor package designed to run on an EyeBot installed in the REV Getz. The Black Box allows critical sensor information to be displayed on the EyeBot touch screen and saved to a removable disk for external data analysis.

Rohan Mathew

Supervisor: Thomas Bräunl

The REV Project: Electric Vehicle Design Concepts and Project Management

This paper presents a detailed explanation of the basic concepts of electric vehicles and their advantages over common internal combustion driven vehicles. The social, environmental and economic need for change from an oil cantered lifestyle has been introduced, as well as an overview of alternative fuels and previous work relating to electric vehicle design and development. This study found that the present performance characteristics of electric vehicles were particularly suited to commuting and short range racing. This research was furthered by formalising the requirements of a vehicle oriented towards these duties. The design and implementation of a five seater, super-miniature class commuter vehicle with a servicing range of 80-100 km was discussed. A theoretical model to predict the performance of an electric vehicle was developed, and showed that the vehicle was viable for commuter use.

Kelly Naunton

Supervisor: Jasmine Henry

Photovoltaic Devices Configured as Position Sensitive Detectors

Position Sensitive Detectors (PSDs) use the lateral photovoltaic effect to produce a voltage output which varies linearly with respect to the position of a beam of light on the semiconductor surface. The purpose of this study is to improve upon the design of a one-dimensional Ti/c-Si Schottky barrier PSD that has proved to be a well performing device in other studies by this research group. The intention is to improve the device performance in terms of linearity and sensitivity. The non-ideal diode parameters of the devices were also investigated. This work investigates the possible device improvement with two different studies:

- The investigation of the Metal-Insulator-Semiconductor structure PSD; with introduction of an oxide layer of varying thickness via sputter deposition.
- The investigation into the use of a gold zinc alloy for ohmic contacts on the devices, with specific reference the duration and temperature of the sintering stage.

The results of the first study showed that the addition of the oxide layer did not offer any performance improvements over the Schottky barrier device with no added oxide layer. No practical conclusions could be drawn regarding the diode parameters and PSD performance. The results of the ohmic contact study found that the gold alloy made highly linear, low resistance contact to p-type silicon, comparable to aluminium.

Michele Ovens

Supervisor: Thomas Bräunl

Instrumentation for the REV Project, an Electric Vehicle Conversion

In an age of soaring fuel prices and growing concern over climate change, interest in electric vehicle (EV) design and research is mounting. As EV battery and propulsion technologies continue to improve and costs decrease, owning a vehicle which does not emit pollution at the point of use will become increasingly viable for environmentally conscious vehicle owners. One option for car enthusiasts is to convert a combustion engine vehicle to electric drive. The conversion of a 2008 Hyundai Getz to electric drive has been undertaken by students at the University of Western Australia as part of the Renewable Energy Vehicle (REV) project. In an EV conversion, new instruments need to be designed to sample and display crucial EV

specific parameters such as battery voltage, current and state-of-charge to the driver. For the UWA vehicle, this data will be logged by on on-board controller for performance analysis.

Tim Pyper

Supervisors: Kamy Cheng/Thomas Bräunl

Renewable Energy Vehicle (REV) - Power Steering, Air conditioning, Traction Motor

There is an increasing need to reduce the carbon dioxide levels currently produced in the transportation sector. Currently 23% of worldwide CO2 is due to transportation, of which personal motor vehicles account for 75% of that. The aim is to find a suitable method of transport that is both cost effective and zero emission, and reduce the increasing reliance on fossil fuels. The renewable energy vehicle is a possible solution to this need. There is an electric drive motor that receives energy from an onboard energy supply or storage.

The energy being supplied is from renewable sources such as solar, wind or thermal energy. There are several problems with this; the current technology uses heavy expensive and bulky batteries to store the energy. Costing more than AU$10,000 per vehicle, the limited range approximately 100km and the long recharge time. There are safety concerns due to heavier vehicles, braking distance and dynamic handling. There are also issues relating to the safe disposal and effective recycling of used batteries, and other components such as lead and mercury in the electronics. This report investigates some of the aspects relating to the function of Electric Vehicles, the Air-conditioning, Power steering and the primary drive or Traction motor.

Evgeni Sergeev

Supervisor: Thomas Bräunl

Multimodal Behaviour Learning for Mobile Robots

From a top-down analysis of robotic programming techniques in the context of service robots we derive the requirements of such systems to incorporate a high-level planner, a behaviour-based layer responsible for addressing unstructured problems, and machine learning modules for working with specific, complex motions. We identify rapid traceability of observed aspects of behaviour back to the modules causing these aspects as the most important element for large-scale systems. This strategy is implemented in a software prototype applied to the task of navigation in a cluttered, maze-like environment. Its behaviour-based layer achieves traceability through a flexible framework of general-purpose event monitors and behaviour rules.

Record-and-replay functionality is available. A Q-Learning module is applied to the task of basic trajectory learning, allowing both unsupervised learning and learning from a human operator.

Justin Ward

Supervisor: Thomas Bräunl

RoBIOS Library Design for the EyeBot M6

Embedded robotics are having an ever increasing role in day to day life. As robots have become more complex they are making their way into our homes to perform simple chores (iRobot Corporation 2008). The EyeBot M6 is the next in a line of vision robots that began with the EyeCon – short for EyeBot Controller (Bräunl 2003). This latest design aims to provide stereo vision, as well as updating the processor, input/output (I/O) devices (i.e. the inclusion of Bluetooth and USB) and for the first time in the EyeBot series, uses an FPGA to handle most of the robotic I/O as well as controlling the cameras.

This hardware platform was initially designed in 2006, with a Gumstix SBC (Single Board Computer) as the main processor and a Xilinx FPGA operating the cameras servos, motors, etc. (Blackham 2006). Hintermann (2007) then went on to implement a LCD library of functions for the RoBIOS (Robot Basic Input Output System). This paper presents new functionality to this LCD library, as well as development of Bluetooth for the RoBIOS and the addition of a GPS to the library. These features will allow the new EyeBot to enable designs even more sophisticated than the previous version, the EyeBot M5.

Jocelyn Williams

Supervisor: Thomas Bräunl/Chris Croft

UAV Sensor Technology

Different sensors are subject to continuously developing technology. With industry innovations resulting in much smaller and faster sensing devices, new and improved applications can be directed towards unmanned aerial platforms.

Unmanned Aerial Vehicles (UAVs) are becoming a common component in both defence and commercial operations. Typical sensor implementations include inertial measurement units, GPS, radar and electro-optical devices. These devices are applied to navigation, attitude and imaging determination.

This thesis reviews and compares different sensor technologies, and their applications to UAVs.

Stephen Whitely

Supervisor: Thomas Bräunl

Battery Management, Power Supply and Safety Systems in an Electric Drive Vehicle

There is currently a great focus on reducing carbon emissions and fossil fuel consumption by means of alternative energy sources in transportation. An increasingly popular option is the electric vehicle (EV). One of the main criticisms on EVs is their limited range. Range

is largely dictated by limitations of the batteries carried in the vehicle. Battery technology is continuously improving but in order to get the most out of current and future technologies, intelligent battery management and efficient use of the energy is required. The management of charging and discharging of the batteries can allow for increased range and extended battery life on current technology and can be applied to new battery technologies as they become available. This paper will cover the installation and implementation of battery management, power supply and safety systems in a conventional vehicle converted to electric drive for the Renewable Energy Vehicle (REV) Project at the University of Western Australia. These systems will be based on a Lithium ion battery pack and will be predominately using currently available technologies to provide a simple conversion that could be achieved by general members of the public without access to high tech labs and workshops. These systems will be tested and reviewed for their strengths and shortcomings. Suggestions will be made as how to improve the systems for future works by the REV Project in ongoing years. This paper shows that while the systems are adequate, a number of improvements on battery management, efficient power distribution and safety issues can be made.

Dyi Zen Tan

Supervisors: Kamy Cheng/Thomas Bräunl

Design and Construction of Motor Mounts For Renewable Energy Vehicle

In Australia the large number of internal combustion engine (ICE) vehicles produces a high degree of pollutants and greenhouse gasses. To address this, the UWA Renewable Energy Vehicle team aims to demonstrate the viability of using renewable energy sources for transport by building an electric commercial car from an ICE car. The goal is to register the fully converted car as a licensed road vehicle. This thesis describes the evaluations of parts retainability, the methodology used in the design and construction of motor mounts, as well as performance evaluation of the finished product.

The early stage of motor installation requires an investigation and evaluation on parts in the engine compartment in order to identify particular parts retainability. All of the evaluations were based on passenger comfort, safety and vehicle performance to determine the retainability of particular parts. In this project, a motor mount was designed to mount the motor in the engine compartment. All the motor mount designs must comply with the Australia Design Rules 2008 and National Code of Practice for light vehicle construction and modification. In addition, analysis such as fabrication cost and complexity, material cost and fabrication time was considered. A performance evaluation was conducted on the finished product. The complete electric car is aimed to launch at the end of 2008. Although the motor mounts had been constructed and had achieved a huge success, there is much room for improvement in the performance of the electric car project.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