THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

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Engineering, Computing and Mathematics

Centre for Intelligent Information Processing Systems

Annual Report 2009

Centre for Intelligent Information Processing Systems
School of Electrical, Electronic
and Computer Engineering
Faculty of Engineering, Computing
and Mathematics

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REF: LB/CIIPS/2009 Annual Report/15_02_00.

Contents

Director's Report

Starting with two automotive projects in 2008, the year 2009 will now truly be remembered as the "Year of the Car" in CIIPS's history. We have conducted no less than four different automotive projects with the Hyundai Getz and Lotus Elise plug-in Electric Vehicle conversions, the electric Formula SAE race car and the BMW X5 Drive-by-wire and Driver Assistance research projects.

All car projects have proven to be extremely popular with students (we had a total of 45 undergraduate and graduate students working on automotive subjects in 2009), as well as with the press and with exhibitions. We held numerous car demonstrations and exhibitions, including even the Perth Royal Show, and had a large number of newspaper articles, radio interviews and two TV reports.

The success of our "REV Eco" EV conversion culminated in the approval of a new ARC Linkage research project that runs from 2010-2013, which will investigate typical EV charging behaviour, in order to predict future EV infrastructure requirements as well as possible load issues on the electricity grid.

Also very successful was the Robotics and Automation lab, winning one of only ten spots worldwide to participate in the MAGIC2010 robotics competition for cooperating mobile robots. Our UWA team is partnering with Edith Cowen University in Perth and Flinders University in Adelaide for this competition.

As always, CIIPS has enjoyed a steady flow of international academic and student visitors over the year. We will continue to strengthen our overseas ties and encourage international exchanges for their mutual benefits.

Professor Thomas Bräunl

Director
Centre for Intelligent Information Processing Systems

January 2010

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 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 Robotics and Automation 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 four research cars for various aspects of automotive research:

- BMW X5
- Hyundai Getz
- Lotus Elise S2
- Formula SAE Motorsport Race Car

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

CIIPS Administration
Centre for Intelligent Information Processing Systems
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AUSTRALIA

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Fax: +61 (8) 6488 1168
Website: http://ciips.ee.uwa.edu.au/

Members of the Centre

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

Professor Thomas Bräunl,
Dipl.-Inform., MS, PhD, Habil., SMIEEE, MDHV, MSAE
Robotics; Image Processing; Concurrency; Embedded Systems; Automotive Systems
tb@ee.uwa.edu.au

Professor Gary Bundell,
BE, MEngSc, PhD, MIEAust, CPEng, SMIEEE, MIET, CEng
Real-time and Distributed Computer Systems; Computational Modelling;
Software Safety Systems
bundell@ee.uwa.edu.au

Mr Chris Croft
BE, MBA, MIEAust, MGMA
Engineering Management; Project Planning
ccroft@ee.uwa.edu.au

Dr Jasmine Henry
BE, PhD, SMIEEE
Photovoltaics
jasmine@ee.uwa.edu.au

Mr Kevin Vinsen
Strategic Planning Systems; Surveillance Systems; Unmanned Vehicles
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Professor Terry Woodings,
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Software Engineering, Software Metrics
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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
Artificial 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
karen@wasp.uwa.edu.au

Research Staff

Dr Serajul Haque
PhD
serajul@ee.uwa.edu.au

Technical Staff

Mr Ivan Neubronner
Senior Technician
ivan@ee.uwa.edu.au

Administrative Staff

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

Visitors

Dr Hyeong-Joon Anh
Visiting Research Fellow
Soongsil University, Republic of Korea

Mr Benedikt Dietrich
Technische Universität München, Germany

Mr Martin Geier
Technische Universität München, Germany

Mr Markus Kohler, Karlsruhe University of Applied Technology, Germany

Frank Ophelders, TU Eindhoven, The Netherlands

Mr Torsten Sommer
Technische Universität München, Germany

Mr Franz Viertler
Technische Universität München, Germany

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 3.02a

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 3.11

Students

Postgraduate Students

Doctor of Philosophy

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

Mr Adrian Boeing
Design of a Physics Abstraction Layer for Improving the Validity of Evolved Robot Control Simulations (T. Bräunl)

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

Mr Chang Su Lee
A Framework of Adaptive T-S type Rough-Fuzzy Inference Systems (ARFIS) (T.Bräunl/A.Zaknich)

Mr James Ng
Path Planning (T.Bräunl)

Mr Seng Teik Ten
Haptic Control (N. Scott/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
An Exploration of Assumptions in Requirements Engineering (T.Woodings)

Master of Engineering Science

Mr Ian Fergus Hooper
Feasibility Study of Electric In-wheel Motors for Road-going Automobiles (T. Bräunl)

Mr Yves Hwang
An Automated Software Design Synthesis Framework (G.Bundell)

Master of Engineering (Coursework)

Mr Boris Jurisic (J. Henry)

Master of Engineering (ICT)

Mr Roozbeh Anvari (T. Bräunl)
Mr Shihao Bai (T. Woodings)
Mr Budianto Budianto (T. Bräunl)
Ms Rupali Ganguly (K. Haines/T. Bräunl)
Ms Suet Mei Khong (T. Woodings)
Mr Phillip O'Neill (A. Zaknich)
Ms Veena Rappan (T. Woodings)
Mr Adrish Guha Thakurta (T. Woodings)
Mr Andreas Tryti (T. Woodings)

Undergraduate Students

Final Year UWA

William Baldwinson
Calin Borceanu
Steven Bradley
Peter Corke
Colin Dickie
Craig Hahn
Karri Harper-Meredith
Tim Heath
Frans Ho
Michael Huynh
Marius Ivanescu
Daniel Kingdom
Chun Kong
Andrew Morrigan
Grace Ong
Ashley Same
Blake Samuels
Amar Shah
Christian Tietzel
Daksh Varma
Cameron Watts
Stefan Westerlund

International Exchange Students

Tom Banasiak, Notre Dame, USA
Jennifer Berry, Notre Dame, USA
Adam Doster, Notre Dame, USA
Anne Flinchbaugh, Notre Dame, USA
Robert Powers, Notre Dame, USA
William Price, Penn State, USA
Brian Teague, Harvey Mudd College, USA
Tim Wallace, Notre Dame, USA

Postgraduate Degrees Completed

Doctor of Engineering (ICT)

Ms Sujatha Bulandran
An Exploration of Assumptions in Requirements Engineering (T.Woodings)

Doctor of Philosophy

Mr Adrian Boeing
Design of a Physics Abstraction Layer for Improving the Validity of Evolved Robot Control Simulations (T. Bräunl)

Mr Chang Su Lee
A Framework of Adaptive T-S type Rough-Fuzzy Inference Systems (ARFIS)
(A. Zaknich/T. Bräunl)

Master of Engineering Sci (Research)

Mr Yves Hwang
An Automated Software Design Synthesis Framework (G.Bundell)

Master of Engineering (Coursework)

Mr Boris Jurisic
Impact of PV systems on the Sourth West Interconnected System Low Voltage Distribution Networks (J. Henry)

Master of Engineering (ICT)

Mr Shihao Bai
Using Bayesian Belief Networks to Assess Project Success Factors with Subjective Data
(T. Woodings)

Ms Rupali Ganguly
Investigating GPU Programmabililty for Accelerating Gridding Algorithms
(K. Haines/T. Bräunl)

Ms Suet Mei Khong
Measurement and Modelling of the Software Testing Process (T. Woodings)

Mr Phillip O'Neill
Tieline Wireless Broadband Camera
(A. Zaknich)

Ms Veena Rappan
Decision Making Using Bayesian Networks for Optimal Software Release (T. Woodings)

Group Photo

Staff, students and visitors of CIIPS 2009.

Back row, left to right: Shaun Bai, Weiqun Zheng, Ivan Neubronner, Anvari Roozbeh, Andreas Tryti, William Baldwinson, Stefan Westerlund, Cameron Watts, Tim Heath Jurek Malarecki

2nd row, left to right: Markus Kohler, Soo Siang Teoh, Adrish Guha Thakurta, Frank Ophelders, Linda Barbour, Terry Woodings, Thomas Bräunl, Peter Corke

Kneeling, left to right: Caleb Tang, Christian Tietzel, Ken Fogden, Kaksh Varma, Neil Shearn, Jonathan Wan

Automotive Lab

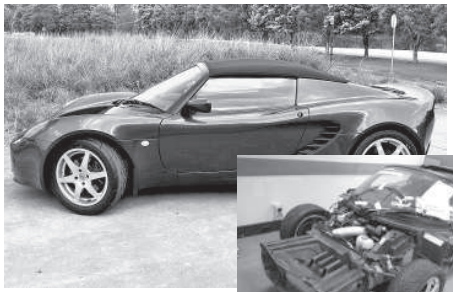
Professor T. Bräunl

The Automotive Lab was established in 2008 and is dedicated to research in alternative drive systems, such as plug-in electric vehicles, as well as active driving safety, such as driver-assistance systems. The Automotive Lab currently houses four vehicles, a BMW X5, a Hyundai Getz, a Lotus Elise S2, and a Formula SAE race car. The Engineering Faculty's REV Project (Renewable Energy Vehicle) runs in this lab. For more detailed information visit: http://robotics.ee.uwa.edu.au/automotive.html and http://theREVproject.com

REV Eco, our first plug-in battery electric car conversion was completed in 2008. During 2009 it underwent a large number of evaluation and durability tests, as well as a number of improvements and modifications. The rear springs have been replaced by student-designed stronger custom springs and a new battery venting system has been designed and installed. The software implementation of the driver information on our own EyeBot M6 embedded controller has been constantly improved and extended with several functions. Using a 3G wireless broadband module, we are now able to transmit the car's GPS position and internal status in real-time over the internet. This allows us to log vehicle information over an indefinitely long time frame and also to investigate vehicle position and status from anywhere in the world. While our original REV Eco design by James Wong was held in green/yellow colours, one of our new

REV sponsors requested a change in colour scheme, so the car has now new decals in red/blue.

Most of 2009's efforts went into the electric conversion of our Lotus Elise S2. The Lotus should have been a simpler project than the Getz, as it is conceptually a much simpler car: no power steering, no brake assist, no air-conditioning – so all these time consuming projects that we required for the Getz, we did not have to do for the Lotus. However, the small space available in this two-seater sports car and the large amount of batteries required turned out to be major problems. We have solved this by providing three separate battery cages, before, over and behind the rear wheels.



A completely new battery management systems (BMS) has been developed by our Senior Technician Ivan Neubronner and we are looking forward to seeing it in action.

The Lotus is being driven by a 75kW three phase DC motor and has a battery capacity of 19kWh (100 batteries of 60Ah each), which gives it a total nominal voltage of 320V. Due to the current reorganisation happening in the Faculty of Engineering, we were not able to get enough workshop hours in order to complete the Lotus in 2009, but we will get there in the first quarter of 2010.

Progress has been made in converting the BMW X5 to steer-by-wire and brake-by-wire, while maintaining its normal drivability. The car is being used as a test vehicle for evaluating vision-based driver assistance systems for lane keeping and collision avoidance. An inflatable copy of the REV Eco has been manufactured to be able to safely test collision (and collision avoidance) scenarios with the BMW.

Quite late in 2009 we finally received a race car chassis from UWA Motorsport, which will be the basis for UWA's first electric Formula

SAE race car. The car is Motorsport's 2001 model and will be converted in two stages. In stage one, during 2010, we will equip the car with two drive motors, one for each rear wheel and an electronic differential. In stage two, during 2011, we will equip the car with four independent wheel-hub motors, developed at UWA.

During 2009, a total of 45 undergraduate and graduate students worked on the REV automotive projects and in addition to their project work donated uncounted hours of their time for the numerous exhibitions and project demonstrations we had over the year. Many thanks for this to all of you.

REV would like to appreciate the support of its 2009 sponsors:

- The University of Western Australia
- BMW Group
- Galaxy Resources
- Gull Petroleum
- WA Department of Transport
- CREST
- Huber + Suhner

High Integrity Computer Systems Lab

Professor G. Bundell, Professor T. Woodings

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 research conducted has been in safety critical embedded systems for the resources industry, specifically in two rail and automation control applications for MRX Technologies. This has involved research into embedded systems development to the various IEC 61508/61511/62278/62279 standards, and development of specific software subsystems for the on-board equipment replacing the train driver.

Postgraduate research linking software component specification and design information to earlier work on software component testing was further progressed (via a PhD) and is expected to be completed in early 2010.

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 continued to be focused on assumptions analysis and this work was submitted for examination 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.

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 res-ponse 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.

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 was restarted in this area and thin film layered structures developed from inexpensive and simple but reproducable techniques will be utilised.

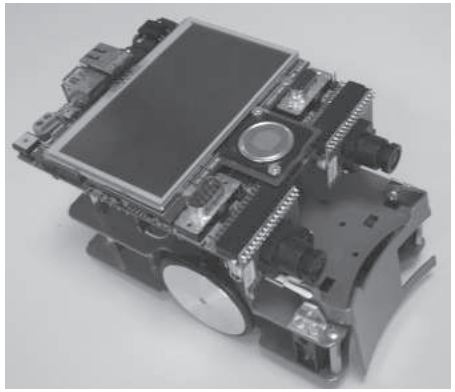
Robotics and Automation Lab

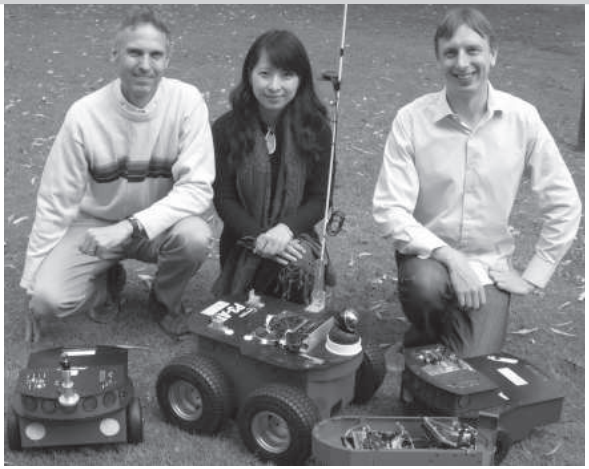
Professor T. Bräunl

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

Software and hardware development has been progressed on the new ARM-based EyeBot M6. It is being used as the main controller of a vision-based automotive driver-assistance system. The system combines a 400/600MHz ARM-9 CPU with an integrated Xilinx FPGA.

The new Soccerbot mobile robot is equipped with digital stereo cameras, three infra-red distance sensors, host-USB, LAN, Bluetooth and a color touch screen.





Our Pioneer-AT outdoor mobile robots will play the central role in our MAGIC2010 competition entry. The newly formed team with members of UWA, ECU and Flinders University has won funding and one of only ten spots worldwide to compete in the 2010 MAGIC mobile robot competition. For this, a heterogeneous group of driving mobile robots has to explore an unknown area and report back data to a command station. The robots will use a variety of sensors, including monocular and stereo vision, laser range finder, GPS, digital compass, and an IMU. Robots will be able to communicate via wireless LAN with each other and the command console, but also have to be operational as a team if wireless communication drops out or one robot becomes disabled or stuck.

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 2009 the Robotic and Automation Lab hosted the following visitors:

Dr Hyeong-Joon Anh
Soongsil University, Republic of Korea

Mr Benedikt Dietrich
Technische Universität München, Germany

Mr Martin Geier
Technische Universität München, Germany

Mr Markus Kohler, Karlsruhe University of Applied Technology, Germany

Frank Ophelders, TU Eindhoven, The Netherlands

Mr Torsten Sommer
Technische Universität München, Germany

Mr Franz Viertler
Technische Universität München, Germany

Systems Engineering Analysis Management Lab

Mr C. Croft

SEAM was established as a vehicle to undertake a wide range of differing projects, usually in conjunction with other groups or researchers. The group has two major areas of interest, the management of systems in crisis and the development of automated control of remotely piloted vehicles.

The group investigates of a number of issues relating to the use of virtual reality environments to control cameras on remote controlled helicopters and aircraft. This research is focused on simulator sickness and the representation of virtual worlds using minimal graphic elements.

The groups' key research areas cover three major groups. The first relates to the management of systems under stress and focuses on the methods in which management is undertaken in unpredictable systems. The second is the ongoing development of auto piloted flight in small aircraft. With the move into virtual reality, the group are currently building the tools to undertake research into the depiction of non visual virtual environments, for example the futures markets or concentration of pollutants in a vessel.

Publications 2009

Research Book

Haque, S., Togneri, R., Zaknich, A.
Auditory Features for Speech Recognition and Enhancement
VDM Verlag AG & Co. KG, ISBN 978-3-639-18396-2, 2009.

Research Books Edited

Bräunl, T. et al (Eds.)
Progress in Robotics
FIRA RoboWorld Congress 2009, Incheon Korea, August 16-20 2009. Proceedings, Communications in Computer and Information Science CCIS 44, Springer-Verlag, Berlin Heidelberg, August 2009, pp. (IV, 392)

Bräunl, T. et al (Eds.)
Advances in Robotics
FIRA RoboWorld Congress 2009, Incheon Korea, August 16-20 2009, Proceedings, Lecture Notes in Computer Science LNCS 5744, Springer-Verlag, Berlin Heidelberg, August 2009, pp. (IV, 322)

Conference Papers

Bundell, G. A.
Aspects of the Safety Analysis of an On-board Automatic Train Operation Supervisor
Proceedings of the 2009 IEEE International Conference on Systems, Man, and Cybernetics, San Antonio, TX, USA - October 2009, pp. 3323-3330.

Lim, C., Mamat, R., Bräunl, T.
Market-based approach for multi-team robot cooperation
4th International Conference on Autonomous Robots and Agents, ICARA 2009, February 10-12 2009, Wellington, New Zealand, pp. 62-67

Vinsen, K. and Woodings, T.
Risk management in Risky Times
Australian Computer Society Conference, Perth, Australia, September 9th 2009.

Woodings, T., Vinsen, K.
Ethics and Robotics
Australian Computer Society Conference, Perth, Australia, Sept 9th 2009.

Woodings, T. L.
Software Risk Management: An Introduction to some Major Issues
Proceedings of a Symposium on Progress in Software Risk Management, ITEE College, Engineers Australia, Perth, July 2009.

Woodings, T. L.
Practical Software Risk Management
Proceedings of a Symposium on Progress in Software Risk Management, ITEE College, Engineers Australia, Perth, July 2009

Journal Articles

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

Kouchakpour, P., Zaknich, A., and Bräunl, T.
Dynamic population variation in genetic programming
Information Sciences, Vol. 179, No. 8, March 2009, pp. 1078-1091

Kouchakpour, P., Zaknich, A. and Bräunl, T.
A Survey and Taxonomy of Performance Improvement of Canonical Genetic Programming
Knowledge and Information Systems (KAIS) Journal, vol. 21, no. 1, October 2009, pp. 1-39

Conference Chairs and Programme Committees

Bräunl, T.

- International Conference on Autonomous Robots and Agents - ICARA, 10-12 February Wellington, New Zealand
- IEEE Workshop on Computational Intelligence for Visual Intelligence - CIVI, 30 March - 2 April, Nashville, TN
- FIRA World Congress 2009, 25-27 August, Incheon, Korea
- International Conference on Social Robotics 2009, 25-27 August, Incheon, Korea
- 5. International Symposium on Autonomous Minirobots for Research and Edutainment (AMiRE), 25-27 August, Incheon, Korea
- IASTED International Conference on Robotics, Telematics and Applications (RTA 2009), 12-14 October, Beijing, China
- IASTED Intl. Conf. on Robotics and Applications (RA2009), 4-6 November, Cambridge, MA
- 13th International Workshop on Combinatorial Image Analysis (IWCIA'09), 24-27 November, Riviera Maya, Mexico
- 22nd Australasian Joint Conference on Artificial Intelligence (AI'09), 1-4 December, Melbourne, Australia

Vinsen, K.

- 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.
- IEEE Computer Society's Technical Committee on Parallel Processing Member
- IEEE Robotics and Automation Society's Technical Committee on Marine Robotics Member
- Australian Research Council (ARC) Expert of international standing, Assessor of research project proposals

Research Grants/Contracts

Braunl, T.

Study on Factors Affecting the Uptake of Electric Vehicles
CREST, $50,000

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

Vinsen, K.

The Multi-Autonomous Ground Robotics International Challenge (MAGIC) 2010
Joint project team UWA/ECU/Flinders/Thales/ILLIARC $150,000

Adrian Boeing

Supervisor: Thomas Bräunl

Design of a Physics Abstraction Layer for Improving the Validity of Evolved Robot Control Simulations

Robots and their control systems are becoming increasingly complex as growing demands are made for their intelligent operation. Automated design processes reduce the complexity involved in designing robots, often leveraging dynamic simulation technology to evaluate potential robot control system designs. However, physics simulators do not provide a perfect representation of the real world. Subsequently, control systems designed in a virtual world will often fail to transfer to the real world.

This thesis presents the design, implementation and evaluation of the Physics Abstraction Layer (PAL), a uniform component based software interface to multiple physics engines. PAL can be used to validate the results of an automated design process, increasing the likelihood that a controller will function in the real world. All the physics engines fully supported by PAL were evaluated in a set of benchmarks assessing the key simulation aspects including friction and restitution models, collision detection and response, and the constraint solvers. None of the thirteen physics engines evaluated was found to perform adequately in all aspects. This result indicates that multiple physics engines should be combined when evaluating a controller design to achieve valid results.

A genetic algorithm was used to automatically design robot control systems for two application areas. In the first application, a spline controller was evolved for bipedal robot locomotion using the PAL's rigid body simulators and a high fidelity multibody simulator. The controllers evolved using PAL outperformed the controllers evolved using previous approaches. In the second application, a wall following PID control system was evolved for an Autonomous Underwater Vehicle (AUV). The control systems that were evolved using multiple fluid dynamics models outperformed all control ix systems evolved using either a Lagrangian Smoothed Particle Hydrodynamics (SPH) model or a Eulerian model.

The biped and underwater vehicle experiments demonstrated that using PAL to combine physics simulators improved the validity of evolved controllers for complex robots in dynamic environments. In the future, robot simulation packages should provide interfaces to multiple physics engines. This would enable engineers to select the physics engines most appropriate to their task, and increase the likelihood of a control system developed in a simulator successfully transferring to the real world.

Sujatha Bulandran

Supervisor: Terry Woodings

An Exploration of Assumptions in Requirements Engineering

The aim of this thesis is to explore the issue of assumptions made during Requirements Engineering (RE). As the initiating phase of a software development process, RE involves activities which are expected to fulfil the needs of the user. The defects which originate during RE are particularly expensive to rectify when uncovered in the later stages of development.

Assumptions made in RE, particularly during requirements analysis, are a significant source of defects and contribute to the total rework cost of the software. Therefore, there is a need to make visible and verify these assumptions in order to reduce the overall development cost.

This research examines the adaptation of a standard defect detection technique for revealing assumptions during requirements analysis. This is an extension of the previous literature which largely emphasizes the importance of detecting assumptions in software projects via automated tools. A process model for the research, termed the Exploration of Assumptions in Requirements Engineering (EAiRE) has been constructed by defining assumptions in the context of RE. In support, there was a need for a Taxonomy of Assumptions in Requirements Engineering (TARE) to enhance this investigation. Several important principles for detecting and inserting artificial assumptions are defined and explained. Further, two experimental trials were designed (a Scenario Based Experiment and an Assumptions Seeding Experiment).

The results of the experiments demonstrated that assumptions can be detected using the suggested approach. The number of the assumptions detected, particularly in relation to the size of the requirements documents used in this study, exceeded expectations. It is clear that it is worth investing greater effort on the detection and measurement of assumptions in RE since this is where many defects originate. The discovery of assumptions at this initial stage of system development has the potential of significantly enhancing the quality of the delivered software.

Chang Su Lee

Supervisors: Anthony Zaknich/Thomas Bräunl

A Framework of Adaptive T-S type Rough-Fuzzy Inference Systems (ARFIS)

Fuzzy inference systems (FIS) are information processing systems using fuzzy logic mechanism to represent the human reasoning process and to make decisions based on uncertain, imprecise environments in our daily lives. Since the introduction of fuzzy set theory, fuzzy inference systems have been widely used mainly for system modeling, industrial plant control for a variety of practical applications, and also other decision-making purposes; advanced data analysis in medical research, risk management in business, stock market prediction in finance, data analysis in bioinformatics, and so on.

Many approaches have been proposed to address the issue of automatic generation of membership functions and rules with the corresponding subsequent adjustment of them towards more satisfactory system performance. Because one of the most important factors for building high quality of FIS is the generation of the knowledge base of it, which consists of membership functions, fuzzy rules, fuzzy logic operators and other components for fuzzy calculations. It is crucial to generate high quality FIS from a highly reliable design scheme to model the desired system process best.

This thesis proposes a general framework of Adaptive T-S (Takagi-Sugeno) type Rough-Fuzzy Inference Systems (ARFIS) for a variety of practical applications in order to resolve the problems mentioned above in the context of a Rough-Fuzzy hybridization scheme. Rough set theory is employed to effectively reduce the number of attributes that pertain to input variables and obtain a minimal set of decision rules based on input and output data sets. The generated rules are examined by checking their validity to use them as T-S type fuzzy rules. Using its excellent advantages in modeling non-linear systems, the T-S type fuzzy model is chosen to perform the fuzzy inference process. A T-S type fuzzy inference system is constructed by an automatic generation of membership functions and rules by the Fuzzy C-Means (FCM) clustering algorithm and the rough set approach, respectively. The generated T-S type rough-fuzzy inference system is then adjusted by the least-squares method and a conjugate gradient descent algorithm towards better performance within a fuzzy system framework.

To show the viability of the proposed framework of ARFIS, the performance of ARFIS is compared with other existing approaches in a variety of practical applications; pattern classification, face recognition, and mobile robot navigation. The results are very satisfactory and competitive, and suggest the ARFIS is a suitable new framework for fuzzy inference systems by showing a better system performance with less number of attributes and rules in each application.

Yves Hwang

Supervisor: Gary Bundell

An Automated Software Design Synthesis Framework

This thesis presents an automated software design synthesis framework known as Project Calliope. This framework aligns with Harel's automated software development process as it addresses the aspect of automating design and implementation. Project Calliope is based on a Statecharts synthesis approach in the literature. The main goal of Project Calliope is to automatically generate testable Unified Modeling Language (UML) Statecharts that are deterministic, visually manageable and UML compliant. In order to minimise design errors in the generated UML Statecharts, Project Calliope supports model checking through Statecharts execution. In addition, executable code is automatically generated based on the synthesised UML Statecharts. This framework seeks to provide a pragmatic design framework that can be readily incorporated into software development methodologies that leverage UML.

In this thesis, Project Calliope is applied to three simiple applications from Whittle and Schumann's examples and a case study based on a commercial application. They are automatic teller machine, coffee dispenser, an agent application, and a groupware application respectively.

Abstracts of Final Year Project Dissertations

William Baldwinson

Supervisor: Karen Haines

Real-Time Evaluation of Communication Intensive Algorithms on GPUs

Ordinary Differential Equations, or ODEs can be used to describe the general case of a large number of physical phenomenon. An ODE describes how variable changes with respect to its current value and some number of independent variables. It is often not possible to find an algebraic solution to an ODE; that is we cannot find a specific solution. This is especially true when we have a system of interdependent ODEs, sets of ODEs which each have some numerical dependence on the other. In this case it is necessary to solve for the function using numerical techniques. A number of interesting problems can be described as a system of interdependent ODEs.

We particularly focus on aspects of a motion detection algorithm described by Haines in her doctoral dissertation “A parallel Artificial Neural Network modelling nonsynaptic communication in the Lamina Ganglionaris of Musca Domestica.” As an algorithm intended to process video streams, we are constrained by time for each step of a solver. In order to make the best use of information being provided, we must be able to process each frame in a limited time, ranging from 1 25s down to 1 72s depending on the medium. Implementation of a simpler, but similar problem, indicated that using a traditional single core CPU implementation, we are limited to processing images of at most 256k pixels at 25fps. While multicore CPUs are now commonly available, the implementation of suitable programs is difficult, and a better option is available in Graphics Processing Units (GPU).

GPUs have recently become a hot topic in research due to the large number of processing cores optimised for calculations. Several scalable languages have been developed for efficient programming of GPUs, which makes these an ideal platform for intensive numerical processing. Using various GPU optimisation techniques, substantial speed-ups over the CPU implementations have been acheived. Tests have shown it should be possible to process images of over 4096k pixels at 72fps on current generation GPUs. This represents an increase by a factor of almost 50 over the CPU, on a much more scalable platform.

Steven Bradley

Supervisor: Thomas Bräunl

Automotive Simulation System

The Automotive Simulation is a large and complex software project with the goal of bringing a realistic driving simulator to the workbench. Many attributes of this large system require reform and redesign to improve performance and stability. To this end, this thesis discusses the attempt to move AutoSim to a new operating system platform so as to make better use of hardware and leverage the Client/Server architecture of the design.

Peter Corke

Supervisor: Thomas Bräunl

Analysis of the 2009 REV Race Car Suspension

The purpose of this project is to analyse and optimise the suspension system of the 2009 REV race car. An effective suspension system acts as a vibration filter, and protects the vehicle from excitation caused by irregularities in the road.

Suitable coil springs are to be selected for the front and rear of the car, to ensure that both ends do not oscillate violently out of phase after going over a bump. The Half Car Model, which has four degrees of freedom, can be used to simulate the vehicle driving in a straight line. By providing excitation to the wheels, the model can be used to show the vertical accelerations of the sprung mass and the front and rear unsprung masses at different frequencies. The selected spring combination should give the least possible vertical accelerations of the sprung and unsprung masses. A common method of determining the extent of driver discomfort is to measure the vertical acceleration of the sprung mass.

It is also important that the suspension is able to damp the unsprung masses adequately to prevent wheel hop. Wheel hop is the vertical vibrating motion of the wheel between the sprung mass and the road, and has the capacity to impede handling and performance.

The Half Car Model will also be used to determine the effects of changing the amplitude of the assumed road, and changing the damping rate of the wheel.

Colin Dickie

Supervisor: Thomas Bräunl

GPS Tracker for a Renewable Energy Vehicle

In 2008 the Renewable Energy Vehicle (REV) Project completed a conversion of a Hyundai Getz hatchback to run with an electric motor.

This project is the continuation of work to improve the onboard instrumentation systems of the car, by installation of a GPS tracking system. This allows users to track the location and status of the car in real-time from any computer with internet access, facilitating performance evaluation of the car. The system is modular and intended to be expandable for future projects. This paper will examine the design process and give a brief overview of the completed system, concluding with test results and comments.

Craig Hahn

Supervisor: Jasmine Henry

Optimising Energy Usage in the IDEAL-ALVA House: A Roadmap for Concept to Reality

With the effects of greenhouse gases and the possible introduction of an emission trading scheme in Australia it is becoming increasingly important that residential housing maximizes energy efficiency. In 2009, a combined effort between the UWA School of Electrical, Electronic and Computer Engineering and Faculty of Architecture, Landscape

and Visual Arts (ALVA) has resulted in the construction and development of a substantial timber framed dwelling which will be a farm manager's house at the UWA Smart Farm in Pingelly. The objective of the IDEAL-ALVA House project is to create a modern, comfortable habitat while incorporating sustainable practices. The focus of this project is to map out the pathway of making this objective a reality through clever design, consumer awareness of energy usage and suitable choices of housing fixtures and appliances.

Topics covered will include the possible renewable power generation options for the house, energy usage control strategies and the solar-passive design principles. The IDEAL-ALVA House will be connected to the electricity grid but it is planned that the house will eventually be autonomous. As such, renewable power generation options such as solar photovoltaic or wind, or a combination of the two will be considered. Energy maximisation strategies, such as intelligent lighting, will supplement the power generation. Also occupant education on energy utilisation via smart metering will give them greater control over their energy expenditure.

Tim Heath

Supervisor: Thomas Bräunl

Omni-Directional Wheelchair

Since the beginning of 2004, the Centre for Intelligent Information Processing Systems (CIIPS) at the University of Western Australia has been developing an omni-directional wheelchair. Omni-direction vehicles have a third degree of freedom, allowing them to move in any direction, as well as rotate on the spot. This is different to most vehicles which have only two degrees of freedom and cannot move perpendicular to the direction the vehicle is facing. This allows for better manoeuvring and makes the use of a wheelchair in buildings far easier, particularly tasks such as passing through doors, which is quite difficult in a conventional wheelchair.

This paper looks at the progress that has been made on the wheelchair this year. This has involved the development of higher level driving routines, to automate tasks such as following walls and passing through doors. The implementation of these routines has also required improvements to the integration of the motor and sensor systems, which previously interfered with each other, and the simulator model for the wheelchair, which will assist in further work on the wheelchair, with the eventual goal of having the wheelchair able to act fully autonomously within a predefined area.

Frans Ho

Supervisor: Thomas Bräunl

Drive System Design for Lotus Elise Electric Car

The number of internal combustion vehicle used in Australia has increased tremendously and released enormous amount of pollutants and carbon dioxide into the atmosphere. This raises concern for many people about global warming and climate change. The Renewable Energy Vehicle Project in UWA aims to provide solutions by promoting an alternative type of fuel for transportation through the development of performance electric vehicle Lotus Elise.

The objective of this thesis is to determine a suitable transmission for the electric car so that it can achieve an excellent acceleration and top speed of 160 Km/h. The Lotus Elise can use the original PG1 gearbox, aftermarket gearbox or just a single differential known as direct drive. A performance modelling was carried out to select the best option to drive the car and to determine the best gear ratio combinations. The final decision is to retain the original PG1 gearbox. The result showed that while using the first and third gears combination from original gearbox produces the highest acceleration and the desired top speed of 160 Km/h, the second and fourth gear combination gives more practical driving.

The conversion of sport electric car requires a new design of motor mount to fix the electric motor securely in the engine compartment. The motor mount design involves the use of Computer Aided Design and Finite Element Analysis program to model the parts and perform stress analysis. All of the motor mounts have been designed, constructed, and assembled such that it complies with Australian Design Rule 2009.

Michael Huynh

Supervisor: Thomas Bräunl

A Framework for Developing Interactive Scenarios in Projector-Based Augmented Reality

The concept of augmented reality (AR) was first realised over forty years ago. AR describes the phenomenon of superimposing computer-generated graphics onto the real-world environment to provide an enhanced perception of reality. Research and development of AR applications has steadily gained popularity recently because of their potential to aid people with various routines in life.

This project harnesses the versatility of existing technologies in the computer vision domain to demonstrate a proof of concept system, allowing users to realise AR applications. The project also presents the rationale and courses of action taken to implement the system. The intent of this is to enlighten readers on the possibilities of creating seemingly novel applications with the readily available technology around them.

The system makes use of open-source libraries, namely OpenCV and OpenGL, alongside computer vision literature to craft the various critical components of the system to enable the realisation of AR applications. In addition, discussion and analysis of the actions committed during design and implementation were evaluated to provide an indication of their effectiveness. The working prototype of the system consisted of approximately 3,000 lines of combined source code and documentation, excluding example applications.

Marius Ivanescu

Supervisor: Thomas Bräunl

Design of the Drive System and Battery Cage for the 2009 REV FSAE Vehicle

The 2001 UWA Formula SAE (Society of Automotive Engineers) Motorsport vehicle was converted to an electric drive system by the Renewable Energy Vehicle (REV) team for the upcoming Formula SAE student design competition. The aim of this project was to research and design a battery restraint system and a drive mechanism to power the converted Motorsport vehicle.

A waterproof and visually open design for the battery cage was produced in adherance to the national code of practice for the construction and modification of light vehicles. The model was produced in Solidworks before being stress analysed in ANSYS Workbench.

The initially imposed drive mechanism was that of a wheel hub motor. An analysis of the performance requirements determined that 20kW of power and 120Nm of torque were required. Attempts made to source a suitably powerful electric motor that would be able to fit within the current arrangement as the constrained budget did not allow for major modification to the existing vehicle. This lead to the Plettenberg Predator, a brushless DC large scale model aircraft motor, however the required supporting structure confirmed through stress analysis with ANSYS Workbench was heavy and had a high part count due to the necessary reduction ratio and belt load. Additionally, it could not be designed within the budget and time constraints to fully protect the motor from overheating and vibration, which were identified as the primary failure modes of the electric motor outside of their intended application.

The arbitrary wheel hub drive mechanism requirement was lifted and an inboard solution sought. This was using two brushless DC pancake motors and a plate style modular single stage arrangement that could be fully removed from the vehicle for modification and testing. This type of arrangement still has the advantage of fully independent rear wheel control; however the motor was inboard as sprung mass and fully enclosed for protection. Custom pulleys and adjustable idlers needed to be designed and manufactured, as well as modifications to CV joints and drive shafts to support the new design.

Daniel Kingdom

Supervisor: Thomas Bräunl

2009 REV Management and On-Board Embedded Systems

The Renewable Energy Vehicle project consists of three electric vehicle conversions including a 2008 Hyundai Getz, 2002 Lotus Elsie and a 2001 Formula-SAE Motorsport. In addition to electric vehicle conversion projects, a BMW X5 is being converted for drive by wire, with the ultimate goal of Autonomous driving and driver assistance technologies.

The 2009 Semester 2 REV team is made up of 44 Students completing a Third year design project, Final year project, and Post-graduate work and volunteers. The students come from a variety of disciplines including, Electrical and Electronic Engineering, Computer Engineering, Computer Science, Mechatronics and Mechanical Engineering. The author holds the position of Student Manager, and is responsible for administrative and managerial tasks in addition to contributing technically to project.

This document focuses on the technical aspect of the work of presenter, and includes a number of new systems and sub-systems that add new functionality or re-produce functionality that was present before the vehicles conversion. Such systems include: The Hardware Black Box Recorder that collects and stores vehicle information, also supporting an embedded USB Host and 2GB of flash memory; AC and DC power measurement systems capturing the actual power consumption of the vehicle and calculating remaining battery capacity; Battery management functionality to protect the Lithium-Iron-Phosphate (LiFePO4) cells in the vehicles traction battery pack; Galvanic isolation systems to protect digital devices including the EyeBot Controller and finally emulating OEM sensors that existed in the original vehicle including fuel gauge, and tachometer.

Andrew Morrigan

Supervisor: Thomas Bräunl

Vehicle Dynamics of the 2009 REV FSAE Vehicle

In 2009 the Renewable Energy Vehicle Project (REV) received the 2001 UWA Motorsport vehicle with the goal of converting it to a pure plug-in electric race car with the use of hub motors. The main objective was to further the knowledge of the REV team on the dynamics of the REV FSAE Hybrid vehicle so that in future further development can be done to increase its overall performance. This report aims to develop an understanding of vehicle dynamic theory and how the physical properties of the vehicle affect the vehicle's performance. Using the dynamic theory obtained from a number of texts, a numerical analysis of the vehicle was undertaken looking into the steady-state stability and control and transient stability and control characteristics of the vehicle. Once completed the same methods were used to try to ascertain where performance increases could be made by changing the chassis setup, including position of the centre of gravity and wheelbase length. Also included in this report is the design of a data acquisition system and a track testing methodology which will both be of importance in future development. This report has found that through modifications to the weight balance and decreasing the wheelbase, performance gains for maximum driving, braking and cornering accelerations can be made while maintaining the transient response characteristics of the vehicle.

Grace Ong

Supervisor: Thomas Bräunl

Drive By Wire

Drive-by-wire systems in the automotive industry are defined as replacing the mechanical, hydraulic or pneumatic components on vehicle system which are directly concerned with the driving dynamics to electro-mechanical devices (Dürkopp and Klaus, 2002). These changes result in; a decrease in vehicle weight, improved functionality, and facilitating the implementation of active safety systems. The examples of drive-by-wire systems include steer-by-wire, throttle-by-wire and brake-by-wire (Swanson, 2007).

The objective of this project is to interface a collision avoidance vision system using drive-by-wire systems. The collision avoidance system can detect obstacles and then the electronic control unit will generate an output to the actuators that in turn drive the vehicle automatically away from the obstacle. In this paper, design of a drive-by-wire system for steering and braking to be installed in a 2001 BMW X5 without violating the Australian Design Rule 42/04 – 'General Safety Requirement' is presented. The design of the drive-by-wire will use an EYEBOT as the control unit which will drive servo motors to operate the steering and brakes.

Ashley Same

Supervisors: R Chandrasekhar/
Thomas Bräunl

Developing Programs For a Mathematics Laboratory

Many students studying mathematics, from year 11 level, up to the level of second year engineering mathematics at university, struggle with certain mathematical concepts. The purpose of this project was to initiate the construction of a new online mathematics laboratory. The laboratory is comprised of programs that will be used to teach mathematical principles to students at the levels indicated above. Each program explores one practical problem.

The programs were designed to maximize the potential for effective teaching. They need to keep the student's interest, while providing a broad range of useful lessons. They were based around four design principles. These were

1. discovery;
2. concreteness;
3. sensory richness; and
4. logical rigour.

Firstly, a problem was selected for each program. This decision was based on the four design principles. The problems that were selected were the sieve of Eratosthenes, Buffon's needle, Sierpinski's triangle, and Euler's polyhedron formula.

Next, the four design principles were used to decide how to successfully investigate and display each problem. Existing programs were studied. The programs were then implemented, using sound programming principles.

Sage is the mathematical software package that was used. It is very comprehensive, but is also open source, and free of charge. Students can therefore use the programs without any costs incurred. It also provides something known as the Sage notebook, that makes it easy for students to begin running programs, almost instantly. Existing educational programs in Sage were studied, in order to locate the most useful functions that the package has to offer.

A website was also designed for each program, in order to help the student to explore all of the different mathematical concepts that the program introduces. A link to the website was included in each program.

The laboratory is currently available online, at http://sites.google.com/site/mathematics-laboratory. It may be the basis for a comprehensive teaching tool, consisting of very many different programs.

Blake Samuels

Supervisors: Thomas Bräunl/Chris Croft

Embedded Control of a Ball and Plate Balance System

Ball and plate balance systems consist of a plate which can rotate about 2 perpendicular axis with the purpose of stabilising a rolling ball. These balance systems are used to teach and study control system engineering. This project aims to create a simple to construct and relatively inexpensive ball and plate balance system. The objective of the ball and plate system design is for it to be used as a teaching aid at high school and university level.

Strict design criteria were imposed to create an iterative design procedure to select and test the components required for the ball and plate system. A touchscreen has been chosen as the ball sensor and an Atmel AVR Butterfly selected as the microcontroller.

A prototype has been designed and constructed to test the capabilities of the respective components. A PID control algorithm has been developed to control the stability of the system. However, the non-linear dynamics in the prototype mechanical design have inhibited stable control of the system.

The outcome of the project is a final design has been developed from testing of the prototype. The distinguishing feature is the revision of the mechanical design. The CAD drawings of the final design have been submitted to the School of Mechanical Engineering workshop to confirm final costs of labour and components. The design has also been established as simple to construct. The overall cost is actually 10% of the quoted cost of the commercially available CE 151 Ball and Plate Model.

Amar Shah

Supervisors: Kamy Cheng/Thomas Bräunl

Drive-by-wire

Drive-by-wire systems consist of sensors, computers, and actuators, which replace mechanical link or hydraulic controls in a motor vehicle resulting in a decrease in vehicle weight, improved handling, and facilitating the implementation of active safety systems. Elements of a drive-by-wire system are examined and the feasibility of implementing a road-legal (as per Australian Design Rules) system into a Lotus Elise is investigated. Research indicates that a drive-by-wire system cannot be implemented into the Lotus Elise whilst retaining road legality in Western Australia. However, the potential benefits of drive-by-wire systems warrants further research, particularly on the topics of system redundancy, system packaging, multiple actuator interaction, control system architecture, vehicle electrical systems, and force feedback mechanisms.

To further investigate the implications of by-wire safety systems, a design project was initiated to interface a collision avoidance vision system with the steering, brakes and throttle control of a vehicle. Performance requirements for various components were established, and preliminary system designs were considered. Components meeting the optimal requirements were considerably expensive and cheaper alternatives were investigated. An initial system design based on these alternative components is presented.

Christian Tietzel

Supervisor: Thomas Bräunl

Battery Cage Mechanics for the Renewable Energy Vehicle Project

In Australia there is growing recognition of the need for actions to address the increasing effects of global warming. There is therefore a greater requirement for renewable energy technologies. Australia has a heavy dependence on automobile transportation which produces large amounts of green house gases and hence requires an alternative solution. In 2009 the Renewable Energy Vehicle team from The University of Western Australia converted a Lotus Elise sports car into an electric drive system whilst striving to maintain its performance characteristics and road worthiness.

A Hyundai Getz commuter vehicle which was converted in 2008, was analysed throughout 2009, and upgraded where necessary to maximise performance efficiency and comfort. The vehicle is now undergoing approval from the Department for Planning and Infrastructure.

This project is responsible for the placement, design and construction of the battery cages for the Lotus Elise. The placement depends upon many factors such as the centre of gravity and axle loadings which will also affect the performance of the vehicle. The design is required to adhere to the rules set out in the national guidelines for the installation of electric drives in motor vehicles which must be read in conjunction with other relevant codes and standards. The battery cages were designed and analysed with the aid of SolidWorks and ANSYS Workbench. They were then constructed and installed predominantly by the UWA Electrical Engineering workshop and are currently operational.

The Hyundai Getz battery cage enclosure was sealed and temperature tested, and an active venting system was designed and installed to maximise the efficiency and lifetime of the batteries. The system is currently operational and automatically controlled by a thermostat.

Daksh Varma

Supervisor: Thomas Bräunl

Renewable Energy Vehicle Instrumentation: Graphical User Interface and Black Box

The current energy conservation and climate change discourse is no longer about lip service to a cause out there in the future. It is a here and now issue focused on alternative energy sources for road transport, fuelled in part by depleting fossil fuels, its increasing costs and the need to control vehicular emissions. One of the most viable solutions available is the Electric Car.

A Hyundai Getz has already been converted into a fully electric car as a part of the Renewable Energy project and a conversion is currently being undertaken on a Lotus Elise. The Getz is road legal, and the Elise will soon be. Both cars have performances similar to their petrol-powered counterparts, but with much better fuel economy and with zero emissions.

This thesis focuses on designing Graphical User Interfaces (GUIs) and developing code for the onboard controllers for both the Getz and Elise. The code is designed to read various sensors, process the data and display it though the GUI. In addition, there is a ”Black Box” implemented in software to record relevant data gathered from the sensors. The onboard controller for the Getz is the Eyebot Mark 6, which runs Busy Box Linux and the controller for the Elise, is a PC running Windows XP embedded. The code for the Eyebot is written entirely in C, while the PC uses a Flash frontend with a Visual C++ backend. The project also focuses on interfacing the sensor hardware with the onboard controllers.

Cameron Watts

Supervisor: Thomas Bräunl

Electrical design and construction of the renewable energy project vehicles

Due to the current social climate and fear of depleting world oil recourses there has been a recent strengthening in the movement to research and develop technologies that reduce the ‘carbon footprint’ of the average person. One of the main conceptual benefactors of this recent interest has been the Electric Vehicle. Recently, major technological advances in battery construction have made it viable to create a car that is run solely on the

power supplied by batteries. However, historically, these new advances in technology have been met with a great deal of resistance from the automotive industry.

Due to this lack of support and the rapid development of Electric Vehicle technologies there are many myths circulating about the performance of electric vehicles. Thus, in order to dispel these myths, the Renewable Energy Vehicle (REV) project is endeavouring to produce reliable, high performing, efficient electric vehicles that are powered completely by renewable energy sources. This is accomplished by retrofitting existing production cars with electrical drive systems powered through a system of rechargeable batteries.

Within these conversions, a functional electrical system is essential to the safety, reliability and practicality of the modified vehicle; and as such detailed planning, research and development of the electrical system needs to be undertaken in order for the conversion of an electrical vehicle to be a success. Thus, this project will be focused on the development of functional electrical systems for the REV electric vehicle conversions.

Stefan Westerlund

Supervisor: Karen Haines

Performance Gains of the Graphics Processing Unit Implementation of the AMD Core Math Library

The AMD Core Math Library (ACML) is a maths library optimised for AMD processors. Among the functions offered are fast and vector versions of math functions, such as trigonometric functions, logarithms and exponentials, Fast Fourier Transforms (FFTs), random number generators, and a variety of linear algebra functions.

AMD have determined that ACML would benefit from being accelerated by using a Graphics Processing Unit (GPU) to perform some of the calculations. GPUs can perform higher than CPUs because they have a much greater number of cores and floating-point units than conventional CPUs. This means that they can perform a greater number of floating point operations per second, even with a slower clock speed. Therefore, AMD have released a version of ACML, called ACML-GPU, that has two common linear algebra functions accelerated by the GPU, single- and double-precision matrix multiplication. This library benefits users by the increased processing speed from GPUs without the need to learn how to program GPUs themselves or knowing how to write efficient parallel algorithms. However, the performance of the new ACML-GPU library has yet to be benchmarked.

The purpose of this project is to benchmark the performance of ACML-GPU and compare it to the benchmarked performance of the CPU-based ACML. The performance of the two libraries will be measured using the High Performance Linpack (HPL) benchmark. HPL measures the time a system takes to solve a system of linear equations, and compares this to how many floating point operations are needed to perform the calculation. The HPL benchmark is used for the Top500 project to determine the fastest supercomputers in the world.