THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

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Engineering, Computing and Mathematics

Computational Intelligence Information Processing Systems

Annual Report 2010/2011

Computational Intelligence Information Processing Systems
School of Electrical, Electronic and Computer Engineering
Faculty of Engineering, Computing and Mathematics

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REF: LB CIIPS 2010/11 Annual Report

Contents

Foreword from the Head of CIIPS

Starting with this annual report, we have adapted our time coverage to match the academic year, rather than the calendar year. So this report for 2010 and 2011 actually covers one year and a half. Another change is our status/name change from a centre to a group, which is a result of the Faculty of Engineering, Computing and Mathematic's (FECM) policy change,

The academic year 2010/11 was one of the most successful in CIIPS history. On the robotics side, we achieved a place in the finals of the international high profile MAGIC 2010 Robot Challenge by beating all other Australian entries. Our Perth-based team comprised members from UWA, ECU and Thales. We built seven cooperating intelligent "WAMbot" robots and took them to the finals at the Adelaide Showgrounds to compete against the best robot teams in the world as the only remaining Australian team.

On the automotive side, we completed and officially launched the REV Racer, an electric conversion of a Lotus Elise sports car, and the REV SAE-Electric single-seater race car. REV extended into the community with two Australian-first EV trials now underway. All 11 EV-converted Ford Focus, built by Perth-based company EV Works in cooperation with CIIPS/UWA, are on the road, while the first of 23 EV fast-charging stations has been installed in Perth.

As always, CIIPS had a number of international visitors over the year and we are very happy to see them contribute to our research projects. We will continue our CIIPS policy to facilitate student exchanges wherever possible.

Professor Thomas Bräunl

Head
Computational Intelligence Information Processing Systems (CIIPS)

June 2011

Introduction to the Group

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

The group combines an active teaching program 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) programs within the School of Electrical, Electronic and Computer Engineering.

The group is active in the areas of artificial neural networks, embedded systems, digital signal processing, image processing, mobile robots, parallel and reconfigurable computing, pattern recognition, electromobility and automotive systems.

Strong and successful collaboration between the group 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 group 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 group also provides about 30 autonomous mobile robot systems in its Robotics and Automation Lab and five research cars in the REV Automotive 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 group currently has five research cars for various aspects of automotive research:

- BMW X5 (Drive-by-wire)
- Hyundai Getz (Electric conversion)
- Lotus Elise S2 (Electric conversion)
- 2010 Formula SAE — Electric Race Car
- 2011 Formula SAE — Electric Race Car (under construction)

Capabilities

The capabilities of the group 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 group is well placed to do pure research, applied research, research and development and contract research.

Contact Details

CIIPS Administration
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Fax: +61 (8) 6488 1168
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Members of CIIPS

School of Electrical, Electronic and Computer Engineering

Professor Thomas Bräunl (Head of CIIPS)
Dipl.-Inform., MS, PhD, Habil., SMIEEE, MDHV, MSAE
Electromobility; Automotive Systems; Robotics; Image Processing; Concurrency; Embedded Systems
thomas.braunl@uwa.edu.au

Dr Adrian Boeing
BE, PhD, MIEEE
Robotics; Automation; Physics Simulations; Computer Graphics; Computer Vision
adrian.boeing@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
gary.bundell@uwa.edu.au

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

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

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

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

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

WASP (Western Australian Supercomputer Program)

Professor Karen Haines
PhD
Director, WASP: Supercomputing; Parallel Processing; GPU Programming
karen.haines@uwa.edu.au

ICRAR (International Centre for Radio Astronomy Research)

Research Associate Professor Christopher Harris
christopher.harris@uwa.edu.au

Research Associate Professor Kevin Vinsen
Strategic Planning Systems; Surveillance Systems; Unmanned Vehicles
kevin.vinsen@uwa.edu.au

Technical Staff

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

Professional Staff

Ms Linda Barbour
CIIPS Secretary/Administrative Assistant
linda.barbour@uwa.edu.au

Visitors

Mr Roozbeh Anvari
Azad University of Tehran, Iran

Mr Valentin Falkenhahn
Universität Stuttgart, Germany

Mr Markus Kohler
FH Karlsruhe, Germany

Mr Frank Ophelders
TU Eindhoven, The Netherlands

Mr Sushil Pangeni
PEC University of Technology, India

Mr Torsten Sommer
Technische Universität München, Germany

Mr Thomas Walter
Universität Stuttgart, Germany

CIIPS Research Labs

Automotive Lab

Professor Thomas Bräunl
REV (Renewable Energy Vehicle), BMW X5 Drive-by-Wire
Location: EECE G.50

High Integrity Computer Systems Lab

Professor Gary Bundell, Professor Terry 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

Professor Anthony Zaknich
Adaptive Self-Learning Systems, Intelligent Signal Processing, Audio and Underwater Applications
Location: EECE 3.11

Photovoltaic Lab

Dr Jasmine Henry
Photovoltaic Devices and Systems
Location: EECE 1.67

Robotics and Automation Lab

Professor Thomas Bräunl, Dr Adrian Boeing
Intelligent Mobile Robots, Embedded Systems, Image Processing, Automotive Systems, Simulation
Location: EECE 3.13

Systems Engineering Analysis Management Lab

Mr Chris Croft
Applied Engineering Projects, Project Planning and Management
Location: EECE 3.11

Current Students

Doctor of Philosophy

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

Mr Lixin Chin
Embedded Vision (T. Bräunl/M. Alder)

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

Ms Sarah Hatton
Software Requirements Prioritisation and the Management of Interactions. (T. Woodings/ M. Reynolds)

Ms Fakhra Jabeen
Automotive Charging and Customer Choice (J. Taplin/T. Bräunl)

Mr Eng Soon Kho
IT Management Frameworks and Standards (T. Woodings)

Mr Yiwei Liu
Automotive Charging and Geo-Networks (T. Bräunl)

Mr James Ng
Path Planning (T. Bräunl)

Mr Robert Reid
Embedded Vision (D. Huynh/T. Bräunl)

Mr Jithin Sankaran Kutty
SIMD Vision (T. Bräunl)

Mr Seng Teik Ten
Haptic Control (N. Scott/T. Bräunl)

Mr Soo Siang Teoh
Robust vision-based vehicle detection and tracking algorithms (T. Bräunl)

Mr Azman Muhamed Yusof
Vision Tracking (T.Bräunl)

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

Master of Engineering Science

Mr Ian Fergus Hooper
REV Wheel-Hub Motor Design (T. Bräunl)

Master of Science

Ms Lesley Lu Zhang
Assessing Software Engineering Quality Assurance (T. Woodings/R. Cardell–Oliver)

Master of Engineering (ICT)

Mr Roozbeh Anvari (T. Bräunl)
Mr Mark Boulton (T. Bräunl)
Mr Xin Cen (T. Bräunl)
Xuan (Sean) Cheng (T. Bräunl)
Mr Frank Yi Tan (T. Bräunl)

Final Year Electrical/Computer/ Mechanical/Mechatronics Engineering

Mr Sachin Castelino (2010/2011)
Mr Nicholas Cockran (2010/2011)
Mr Karri Harper-Meredith (2010)
Mr Daniel Harris (2010)
Mr Paul Holmes (2010)
Mr Alex Hukins (2011)
Mr Marcin Kiszko (2011)
Mr Jonathan Oakley (2010/2011)
Mr Alexander Ottenhoff (2010)
Mr John Pearce (2010)
Mr Nicholas Randell (2010)
Mr Scott Richards (2011)
Mr Jeon Singh (2011)
Mr Tom Skevington (2011)
Mr Edward Walthew (2011)
Mr Matthew Webster (2010/2011)
Mr Timothy Yates (2010)

Postgraduate Degrees Completed 2010/2011

Doctor of Engineering

Mrs Sujatha Bulandran
An Exploration of Assumptions in Requirements Engineeirng. Thesis submitted for examination (T. Woodings)

Doctor of Philosophy

Mrs Sabrina Ahmad
Measuring the Effectiveness of Negotiation in Software Requirements Engineering. Thesis submitted for examination (T. Woodings)

Mr James Ng
An Analysis of Mobile Robot Navigation Algorithms in Unknown Environments (T. Bräunl)

Master of Computer Science

Mr Adam Khalid
Automatic Testing of Java Code Written by Novice Programmers (T. Woodings/R. Cardell–Oliver)

Ms Niyosha Rahbar
A Diagnostic Tool for Improvement of Software Project Estimation (T. Woodings)

Master of Engineering (ICT)

Mr Roozbeh Anvari
FPGA Implementation of the Lane Detection and Tracking Algorithm (T. Bräunl)

Mr Mark Boulton
Vision Based Obstacle Detection and Multi Robot Object Position Estimation (T. Bräunl)

Mr Xin Cen
Driver-Assistance System (T. Bräunl)

Mr Troy Epskamp
A Software Process for Auto-Coding Using MATLAB/Simulink (T. Woodings)

Mr Frank Yi Tan
Telemetry (T. Bräunl)

Automotive Lab

Professor Thomas Bräunl

The Automotive Lab was established in 2008 and is dedicated to research on driving economy, such as plug-in electric vehicles, as well as active driving safety, such as driver-assistance systems. The Automotive Lab currently houses five vehicles, a BMW X5, a Hyundai Getz, a Lotus Elise S2, and two Formula SAE race cars. The Engineering Faculty's REV Project (Renewable Energy Vehicle) runs in this lab. Details can be found at: http://robotics.ee.uwa.edu.au/automotive.html and http://theREVproject.com

REV Eco, our first plug-in battery electric car conversion, based on a small commuter Hyundai Getz, completed in 2008. It took us almost two years, to complete the conceptually much simpler REV Racer, based on a Lotus Elise S2. Although the Lotus has no power steering, no brake assist and no air-conditioning, the lack of space, pay-load and accessibility made the Lotus conversion a real challenge. The rear of the car had to be significantly reinforced in order to support the weight of 83 Lithium-Ion-Phosphate batteries in three separate battery cages.

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.

Also launched in 2010 was REV's first version of a Formula SAE–Electric single seater race car. In this new international competition, students build an electric powered race car to compete in a driving and engineering challenge with other university teams. The REV 2010 SAE–Electric car is equipped with two drive motors, one for each rear wheel and uses an electronic differential.

For 2011, a new car is being designed and built from scratch and will feature four independent wheel-hub motors, developed at UWA.

November 2010 saw the first public Level–2 fast-charging station in Australia installed at the RAC Headquarters, West Perth. This charging station is used as part of the ARC Linkage network of fast-charging stations.

During 2010/11, a total of 23 undergraduate and graduate students worked on the REV automotive projects. In addition to their project work, they donated uncounted hours of their time for the numerous exhibitions and project demonstrations we had over the year. Many thanks to all involved!

In 2010/11 the Automotive Lab hosted these visitors:

- Thomas Walter, University of Stuttgart, Germany
- Markus Kohler, FH Karlsruhe, Germany

REV appreciates the support of its 2010/11 sponsors:

- Faculty of Engineering, Computing and Mathematics, UWA
- BMW Group
- CREST
- Galaxy Resources
- WA Department of Transport
- Gull Petroleum
- Altronics
- Huber + Suhner
- EV Works
- Swan Energy

REV Spec Sheet	REV Eco (2008)	REV Racer (2009/2010)
Base car	2008 Hyundai Getz	2002 Lotus Elise S2
Seats/doors	5 seats / 5 doors	2 seats / 2 doors
Original engine	1.4l, 4 cylinders, 70kW	1.8l, 4 cylinders, 116kW
Electric motor	Advanced DC FB 4001, DC	UQM Powerphase75, AC
Controller	Curtis 1231C, 500A	UQM DD45-400L, 400A
Power, Torque	28kW, 136Nm	75kW, 240Nm
Regenerative braking	No	Yes
Instrumentation	EyeBot M6	Automotive PC
Batteries	Lithium-Ion-Phosphate, 45 x 90Ah	Lithium-Ion-Phos.,83 x 60Ah
Battery weight	135kg	191kg
Voltage	144V	266V
Total capacity	13kWh	16kWh
Total weight (petrol, electric)	1160kg, 1160kg	780kg, 936kg
Top speed	125km/h	200km/h (estimate)
Range	80km road-tested	100km road-tested
Charging Time	6h (full charge)	6h (full charge)

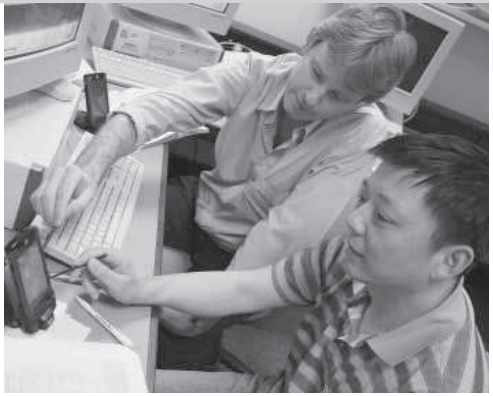
The BMW steer-by-wire in collision avoidance testing

REV Student Manager Ian Hooper and REV Director Thomas Bräunl with WA Minister for Environment Bill Marmion.

Left: The Lotus Elise charging-up at RAC Headquarters in West Perth; Right: WA's first Level-2 fast-charging station.

High Integrity Computer Systems Lab

Professor Gary Bundell,
Professor Terry 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 systems.

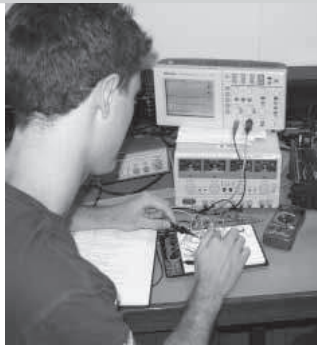
The main research conducted has been in safety critical embedded systems for the resources industry, specifically in two rail and automation control applications for MRX Technologies. This has involved research into embedded systems development to the various IEC 61508/61511/62278/62279 standards, and 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 2011.

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 in this area has continued to be focused on assumptions analysis.

Integrated Sensory Intelligent Systems Lab

Professor Anthony 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 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.

Photovoltaic Lab

Dr Jasmine 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 is mainly undertaken by final year project students, although it has received financial support from the Minerals and Energy Research Institute of WA. In 2010 and 2011 work has continued in this area and thin film layered structures developed from inexpensive and simple but reproducable techniques will be utilised.

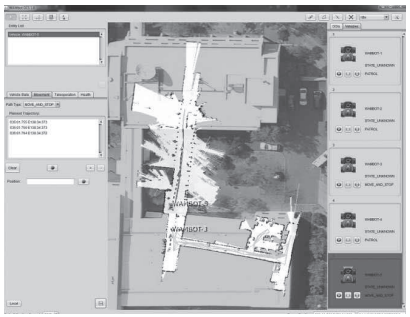
Robotics and Automation Lab

Professor Thomas Bräunl, Dr Adrian Boeing

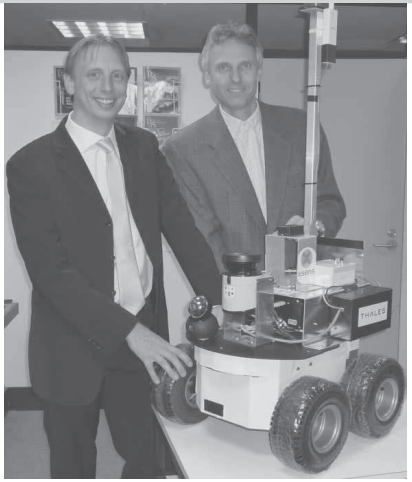
The Robotics and Automation Lab was established in 1998 and is dedicated to research in intelligent autonomous mobile systems. Using embedded systems, over 50 mobile robots have been designed in the lab, while the development of simulation systems also plays a major role in the lab's research efforts. Details can be found at: http://robotics.ee.uwa.edu.au

The CIIPS Robotics and Automation Lab, in conjunction with members from Edith Cowan University and Thales Australia competed in the Multi Autonomous Ground-robotic International Challenge (MAGIC 2010). Our team "Western Australian Magic Robot" (WAMbot) finished 4th overall, a considerable achievement in the USD$1.1 million dollar international robotics competition.

MAGIC 2010 was jointly coordinated and sponsored by the Australian and US Departments of Defence (DSTO and RDECOMM). Their goal was to encourage the development



Robot mapping example



Adrian Boeing and Thomas Bräunl with WAMbot

of next generation fully autonomous ground vehicle systems that could be deployed effectively in emergency situations. The challenge required demonstration of a multi-vehicle robotic team that could execute intelligence, surveillance and reconnaissance missions in a dynamic urban environment.

The challenge was announced in July 2009. The WAMbot proposal was selected in October 2009 as one of the 12 short-listed teams and was awarded USD $50,000 in funding. In June 2010 the DSTO and RDECOMM assessment panel visited UWA where the team demonstrated a set of functional components. MAGICian/WAMbot was one of six teams further short-listed for the finals and awarded another USD $50,000 in funding. WAMbot was the sole Australian team, with three teams from the US, and one team each from Japan and Turkey.

The MAGIC 2010 challenge was held on the 7th to 12th of November in Adelaide, South Australia. Three weeks prior, five robots were shipped to Adelaide and two team members flew over. Using facilities at Flinders University the team continued fine-tuning and testing the robots around campus. A week before the competition the remaining team members arrived in Adelaide with another two robots. Final preparations and testing continued with the team working very hard and long hours. Two days before our competition date the team moved to the Hampstead Army Barracks where we continued with final testing and mission rehearsals.

The Adelaide Royal Showgrounds were used for the challenge as a mock urban environment. The remaining five finalists were scheduled on consecutive days, with our team's challenge day up first. The challenge was run as a high-security operation behind closed-doors. Our robots were stored and operated from army tents. The challenge day began at 5.30am on November 7th. The team arrived in the morning to find them covered in a heavy dew and unfortunately several pieces of hardware were damaged. Five robots checked out and were mostly operational with only a few broken GPS units. The challenge proceeded and we began the first phase. Unfortunately the damaged hardware hampered efforts and not all the required objectives were achieved. The WAMbot team

continued with the second and third phases of the competition, again restricted by hardware problems.

In the days following the challenge the remaining team members worked to repair the robots and prepared for the "Old Ram Shed Challenge", a separate challenge for media and VIPs. Five robots were presented at the challenge and successfully explored the entire mission area. The team received considerable interest from Australian Defence, DSTO and other guests.

The robots were then packed and shipped to Brisbane for the Land Warfare Conference where they were put on display at both the DSTO and Thales Australia stands performing demonstrations and receiving significant interest. Technical presentations were given by each team and the winners were announced. University of Michigan, University of Pennsylvania and RASR were awarded first, second and third prizes respectively.

The MAGICian Team is indebted to Thales Australia for its strong support as primary sponsor. Thanks also goes to these sponsors: Sick Sensor Intelligence, Real-Time Innovations (RTI), XSens, RF Innovations, AXIS Communications, Mobile Computing Solutions and Freenet Antennas.

The MAGICian Team members:

Adam Gandossi
Adrian Boeing
Aidan Morgan
Anthony Attwood
Brian Frisch
Chang-Su Lee
Frank Ophelders
Kevin Vinsen
Martin Masek
Michael Fazio
Nicolas Garel
Robert Reid
Sam Lopes
Sushil Pangeni
Thomas Bräunl

In 2010/11 the Robotics and Automation Lab hosted the following visitors:

- Mr Markus Kohler, Karlsruhe UAT, Germany
- Frank Ophelders, TU Eindhoven, The Netherlands
- Mr Torsten Sommer,TU München, Germany
- Mr Sushil Pangeni, PEC University of Technology, India

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 group's 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 is 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 2010

Research Book

Bräunl, T.
'Embedded Robotics - Mobile Robot Design and Applications with Embedded Systems' (translation to Chinese)
Xi'an Jiaotong University Press, P.R. China in cooperation with Springer-Verlag, Berlin Heidelberg, Germany. In print 2011

Conference Papers

Boeing, A., Morgan, A., Powers, D., Vinsen, K., Bräunl, T.
'MAGICian'
Proceedings of the Land Warfare Conference 2010, Brisbane, Australia, November 15-19 2010, pp. 347-355

Bundell, G. A.
'Application of a max-min-plus discrete event model to the operation of a heavy-haul iron-ore railway'
Proceedings of the 2010 7th International Conference on Informatics and Systems, Cairo, Egypt, 28-30 March, 2010

Woodings, T.
'Progress in Software Testing'
Proceedings of a Symposium on Progress in Software Testing, ITEE College, Engineers Australia, Perth, July, 2010

Zheng, W., Bundell, G. A., Woodings. T.
'UML-Based Software Component Testing'
Proceedings of a Symposium on Progress in Software Testing, ITEE College, Engineers Australia, Perth, July, 2010

Journal Article

Xiang, J. and Bräunl, T.
'String Formations of Multiple Vehicles via Pursuit Strategy'
IET Control Theory & Applications, United Kingdom, Vol. 4, No. 6, 2010, pp. 1027-1038

Research Grants and Professional Activities

Conference Chairs and Programme Committees

Bräunl, T.

- MASCOTS 2010, 17-19 Aug., Miami Beach, FL
- 7th IFAC Symposium on Intelligent Autonomous Vehicles, 6-8 Sep, Lecce, Italy
- 15th IASTED Intl. Conf. on Robotics and Applications RA2010, 1-3 Nov Cambridge, MA USA
- Intl. Conf. on Social Robotics, 23-24 Nov Singapore
- AI2010, 7-10 Dec Adelaide

Journal Editorial Boards and 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 and Contracts

Bräunl, T., Boeing, A. and Vinsen, K.

MAGIC 2010 Competition

- DSTO/RDECOM, USD$100,000
- Thales Australia, $50,000
- IBEO/SICK, $20,000 (in-kind)
- RTI, MAGIC 2010, $25,000 (in-kind)
- SICK, MAGIC 2010, $25,000 (in-kind)
- Xsens, $10,000 (in-kind)

Bräunl, 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

Abstracts of Postgraduate Dissertations

Sujatha Bulandran

DE(ICT) - Submitted for examination

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.

James Ng

PhD

Supervisor: Thomas Bräunl

An Analysis of Mobile Robot Navigation Algorithms in Unknown Environments

This thesis investigates robot navigation algorithms in unknown 2-D environments with the aim of improving performance. The algorithms which perform such navigation are called Bug Algorithms. Existing algorithms are implemented on a robot simulation system called EyeSim and their performances are measured and analysed.

Similarities and differences in the Bug Family are explored particularly in relation to the methods used to guarantee termination. Seven methods used to guarantee termination in the existing literature are noted and form the basis of the new Bug algorithms: OneBug, MultiBug, LeaveBug, Bug1+ and SensorBug. A new method is created which restricts the leave points to vertices of convex obstacles.

SensorBug is a new algorithm designed to use range sensors and with three performance criteria in mind: data gathering frequency, amount of scanning and path length. SensorBug reduces the frequency at which data about the visible environment is gathered and the amount of scanning for each time data is gathered. It is shown that despite the reductions, correct termination is still guaranteed for any environment.

Curv1, a robot navigation algorithm, was developed to guide a robot to the target in an unknown environment with a single non-self intersecting guide track. Via an intermediate algorithm Curv2, Curv1 is expanded into a new algorithm, Curv3. Curv3 is capable of pairing multiple start and targets and coping with self-intersecting track.

Sabrina Ahmad

PhD—Submitted for examination

Supervisor: Terry Woodings

Measuring the Effectiveness of Negotiation in Requirements Engineering

The requirements engineering activities within a software project are known to be critical to the successful production of a correctly functioning system. This is particularly so when considering the varying views of multiple stakeholders. One promising approach for improving the outcome is to introduce formal negotiation. Clearly, making the set of requirements more closely represent all the stakeholders' perspectives and perceptions, underpins a sound basis for project estimation, improved system quality and a reduction of the resources necessary.

However, such benefits are mere speculation if it is not possible to provide empirical evidence. The purpose of this research was to set up a metric framework to measure a number of key aspects of negotiation within requirements elicitation and validation. A number of experiments and trials were designed and implemented to quantify the expected outcomes of requirements negotiation.

First, negotiation is shown to be beneficial to identify and to resolve conflicts between stakeholders. In particular, it is valuable in the allocation of priorities for a particular requirement and in the decision on its inclusion or exclusion. This is particularly useful in evolutionary and incremental paradigms such as the Agile methods. Also, it is necessary when time and resources are constrained - a condition in most software projects. Whereas this first outcome is hardly surprising, it does validate the fundamental purpose of negotiation.

Second, having demonstrated that negotiation leads to an agreement, there is a need to check whether that consensus is heading in the right direction. The concept of a perfect requirements specification (here termed the "gold standard") is introduced and measurements of progress towards such an ideal are made.

Third, there is a need to measure the quality of the individual requirements. Whereas there has been a great deal of research on software quality in general, there was a need to devise and assess six metrics designed specifically for requirements quality. Their use within a measurement framework was demonstrated in the last experiment.

Finally, the data from one of the experiments was used to quantify the likely return-on-investment for introducing a formal negotiation phase within requirements engineering.

Adam Khalid

MCS

Supervisors: Terry Woodings, Rachel Cardell–Oliver

Automatic Assessment of Java Code Written by Novice Programmers

In this thesis the marking process of computer programs written by novice programmers is studied. Assessment and feedback are two important entities in the student learning process. Delayed feedback will affect the student in their learning process. However academics find marking difficult and time consuming. In this research a new method of marking computer programs is introduced. Automated marking of computer programs is researched in this study. In this research several open source tools that can be used to mark programs automatically are analysed. The software quality factors that are to be assessed in student programs identified. Marking schemes are developed to measure the identified quality attributes. An experiment project is selected. The project is marked using automated marking and manual marking. The results compared. These compared results indicate that there is a high correlation between manual marking and automated marking. It appears that automated marking can be used to mark programming assignments in university programming courses.

Niyosha Rahbar

MCS

Supervisor: Terry Woodings

A Diagnotic Method for Improvement of Software Project Estimation

Obtaining accurate estimates of project size, effort and duration early in the software process has been a long-term goal of software engineering practice. Accurate estimates of software development effort lead to more reliable schedule predictions to ensure the most efficient use of valuable resources. Moreover an accurate estimation result is a crucial element for software industries to remain competitive in the software market; which would have an impact on revenue and expenditure.

Many software estimation techniques have been introduced to improve the estimation accuracy. Nevertheless, due to a variety of reasons the accuracy of the estimation methods is lacking when compared with other engineering disciplines.

The broad objective of this thesis is the project control by means of better estimation. To improve estimation managers need to know about the sources of error and bias. This thesis rests on the idea of Partitioning the Mean Square Error to diagnose the main sources of the variation between estimation and actual results. To search for the weakest areas in projects the actual development process is also examined alongside the estimation phase. Improvements are based on understanding, and controlling the source of the error. Accordingly, estimation improvement strategies are presented to reduce the gap between estimation and actual development results. For the case of the estimation phase as the major cause of the error two strategies are suggested. Size calibration is the first suggestion (when size is the main source of the error). The other strategy is the combination of the estimation methods (when the estimation models are the main source of the error). Adding extra factors alongside size is also suggested when the actual development is the main reason for the variation between estimation and actual results. These strategies are demonstrated with a series of industrial project data, where the gap between estimation and actuals is decreased.

Roozbeh Anvari

MEICT

Supervisor: Thomas Bräunl

FPGA Implementation of the Lane Detection and Tracking Algorithm

The application of Image Processing to Autonomous Drive has drawn significant attention in literature and research. However, the demanding nature of the image processing algorithms conveys a considerable burden to any conventional real-time implementation. Meanwhile the emergence of FPGAs has brought numerous facilities toward fast prototyping and implementation of ASICs so that

an image processing algorithm can be designed, tested and synthesized in a relatively short period of time in comparison to traditional approaches.

This thesis investigates the best combination of required algorithms to reach an optimum solution to the problem of lane detection and tracking while aiming to fit the design to a minimal system. The proposed structure realizes three algorithms, namely, Steerable Filter, Hough Transform and Kalman Filter. For each module the theoretical background is investigated and a detailed description of the realization is given followed by an analysis of both achievements and shortages of the design.

Mark Boulton

MEICT

Supervisor: Professor Thomas Bräunl

Vision Based Obstacle Detection and Multi Robot Object Position Estimation

As society becomes increasingly risk averse to placing people in potentially hazardous situations autonomous robotic systems technologies are being sought as a possible alternative. This is the motivation behind the Multi Autonomous Ground-robotic International Challenge (MAGIC) and in particular, this thesis is a description of several subsystems of a solution entered in the MAGIC 2010 competition.

In order for any autonomous robot to navigate through its environment, it must be able to avoid collisions with objects in the environment. In addition, for multiple robots to collaborate and find the same object in a newly mapped environment a solution that combines all object position reports and creates a single estimate for the position of these objects is essential. This thesis describes issues associated with obstacle avoidance and position estimation for objects of interest, and presents implemented solutions to these problems. Also presented are the design, implementation and analysis of these systems as they relate to their integration into a MAGIC 2010 solution.

For obstacle avoidance, two solutions are presented, firstly one using colour histogram matching and the other using stereo vision with ground plane projection. Colour histogram matching assumes that all free path space around the robot will have a very similar colour histogram to that of the patch directly in front of the robot, quite a valid assumption in structured environments. The stereo vision solution takes advantage of the inherent 3D information in stereo imagery by creating a ground plane projection and thus finds objects that are above or below the ground plane.

An expectation maximisation algorithm is used as a solution to object position estimation for static objects of interest. To solve the same problem for mobile objects of interest a weighted average of position information is implemented.

Xin Cen

MEICT

Supervisor: Thomas Bräunl

Vision-Based Lane Detection and Tracking System

A Lane Detection Tracking (LDT) system has been designed already by the REV project BMW team in the School of Electrical, Electronic and Computer Engineering at the University of Western Australia. However, this system still has some weakness and cannot work well in complex road environments. A method to improve this LDT system is given.

In the method presented in this thesis, a re-designed feature extraction filter is used instead of the initial one-to-LDT system improvement. There are those with one-core functions and others with two additional functions in this new designed filter. The core function is an improved Sobe filter. Two additional functions are similar for the darkness area filter. One of them is working before Sobel filter work, the other is working on the result of core function. A method of threshold choice for these filters is also given.

The implementation results of the initial LDT systems and improved LDT systems are given as comparison. Analysis for the comparison is shown. Finally, the weakness of this new LDT system and improvement ideas are illustrated.

Xuan (Sean) Cheng

MEICT

Supervisor: Thomas Bräunl

A GUI Framework for Autonomous Mobile Robotic System

A GUI framework has been developed to address problems in remote controlling of an autonomous mobile robotic system. The autonomous mobiles are equipped with GPS receivers and are capable of performing path finding and obstacle detection autonomously. The GUI enables the operator to monitor the states of the robots and their environmental feedbacks, and control the robots utilizing their autonomous features or manual tele-operation.

A prototype of this GUI framework was developed using Java Swing toolkit and tested by WAMBOT project team members. The testing results verify the effectiveness of the framework although there are deficiencies.

Troy Epskamp

MEICT

Supervisor: Terry Woodings

A Software Process for Auto-Coding Using MATLAB/Simulink

Orbital Australia Pty Ltd is considering using Simulink as its future primary method for Engine Management System development. This research sought answers to the questions Orbital had about transitioning to Simulink related to the software processes that would best suit Simulink and what benefit in effort would result.

A trial evaluation of Simulink was performed examining what parts of the software should be converted, developing a build process and then implemented three control strategies. This trial successfully proved that Simulink would be able to meet Orbital's integration and memory usage criteria.

A new software process for using Simulink to develop control strategy software was created. There were three central concepts of this new process. Firstly, using the Simulink model as an executable design specification to allow requirements and design defects to be found earlier in the process. Secondly, using auto-coding of the Simulink model to improve efficiency. Thirdly, re-testing at each stage of the process using the same test cases generated early in the process to show that no defects were introduced by that stage.

After researching different techniques for documenting software processes, the current hand-coding software process and the new Simulink bases software process were documented. The first stage of the documentation process was to create a top level process diagram based on one of the

software development life-cycle models in Wysocki's taxonomy. The second state was to create Entry Task Verification eXit (ETVX) process descriptions based on a method developed by Westfall.

To understand the benefit in effort that would result from transitioning to Simulink, software process models of the current hand-coding and new Simulink software processes were developed. A number of simulations were performed using these models to estimate the total effort benefit and to understand where that effort benefit comes from in the process. The simulations indicated an 18% decrease in total effort from transitioning to Simulink.

Frank Yi Tan

MEICT

Supervisor: Thomas Bräunl

Development of Electric Formula SAE Real-time Telemetry Software.

The increased popularity of Formula SAE events all over the world has brought an intensive need for an open standard race car telemetry system. The Renewable Energy Vehicle team (REV) at the University of Western Australia is keen on developing such a system for electric Formula SAE cars.

The software part of the telemetry system (named Crystal Ball) has been developed to receive, interpret and visualize real-time data collected from the Formula SAE car. It is designed to provide race engineers an insight into all aspects of the race car. It is expected that Crystal Ball would be released as open source software, to enable collaboration among different teams for further development, and finally to substitute its commercial counterparts.

This dissertation documents the development process of Crystal Ball. It begins by defining the role of the project in the telemetry system, an analysis of existing solutions, followed by an evaluation of essential features and limitations of these solutions. The scope of the project and the requirement is then specified based on iterative requirement engineering, existing system evaluation and resource constraints. The dissertation presents the design and implementation of Crystal Ball, including other design and implementation options. The rationale of the selections is discussed. The software is validated by data simulation, user experience survey and expert evaluation.

Abstracts of Final Year Project Dissertations

Sachin Carl Castelino

Supervisors: Terry Woodings, Kevin Vinsen

Data mining—A Study of Non-performing assets: India

Data mining is defined as the process of discovering patterns in data. The patterns discovered help scientists; researchers and business analysts convert vast amounts of data into information. This study is aimed at finding any relationship between the likelihood of a future account holder being an NPA (non-performing asset) with respect to debt-to-salary ratio, marital status, number of dependents and credit score (this attribute is the result of a scoring module developed by the bank). This thesis also includes the study of the parameters involved in the data mining process and what can be done to improve results, to gain a readable model.

In a financial institution, an NPA is an asset which ceases to generate any income. NPAs are the product of fallout of banks' activities with respect to both management and implementation procedures in relation to credit appraisal system, monitoring of end-usage of funds and recovery procedures. The results obtained from the data mining algorithms can be used by the institution's management to identify potential NPAs.

The algorithms chosen for the study are the J48, Random Tree and Bayesian Networks (search method K2). An initial run of the algorithms on the dataset produced decision tree sizes of 98 and 4054 conditions for the J48 and Random Tree respectively. Producing rule sets from partial decision trees, which uses the principles of the J48 algorithm, also produced 50 rules. On the basis of journal articles and previously done research on this topic, the numeric attributes were prediscretised. The numbers of conditions were now reduced to 42 and 236 for the decision tree and random tree algorithms, respectively. The rules produced by the partial decision trees dropped down to 16. The drop in percentage accuracy was not more than 0.6%, after the attributes were prediscretised . Thus, rule sets were obtained from these models w.r.t. debt to salary ratio, marital status, number of dependents and credit score of the account, to predict the possibility of an NPA. The debt to salary ratio gives a better indication of whether an account is an NPA or not, than the credit scoring module developed by the bank.

Gwendlyn Yew-Min Chua

Supervisor: Jasmine Henry

Impact of a Low Carbon Economy on the Australian Resource and Electricity Sectors

With fears that increases in global average temperatures over recent decades are due to increased greenhouse gases in the atmosphere the Australian government has proposed two schemes: The Emissions Trading Scheme (ETS) and the Mandatory Renewable Energy Target (MRET). These schemes aim to reduce carbon emissions in Australia.

This thesis aims to model the effects of the ETS on the Australian resource sector and is the first model of its kind. The coal industry was used for analysis, as it is expected to be the most heavily affected. MS Excel was used to model the effects of cap pathways, government assistance packages and carbon permit prices to determine the impacts on its ability to meet the midterm emissions target, product demand and product price.

As well as the Goverment's cap pathway, two cap pathways, linear and logarithmic, were designed and analysed to achieve the 2020 emissions target. Results show the logarithmic pathway as the most favourable. It produced similar impacts on coal prices and production levels as the linear pathway but with higher revenue from entities purchasing

permits. Assistance packages were found necessary for industry survival, but led to a small decrease in price as compared to the reference model results from 2010 to 2012. The Electricity Sector Adjustment Scheme (ESAS) offered to coal-fired power stations was also found sufficient in achieving Carbon Pollution Reduction Scheme (CPRS) objectives, without being too generous. Results indicate permit prices between $10 and $20 would be best to acheive minimised price increase for consumers whilst retaining companies' international competitiveness.

The proposed CPRS has the potential to curb carbon emissions in Australia, however the legislation is yet to be passed. Other carbon emissions mitigation measurements should be considered as an alternative method or to complement the proposed CPRS, such as the Mandatory Renewable Energy Target (MRET).

The second part of this project investigates scenarios for Australia to produce 20% of its electricity using renewable energy sources by 2020. The renewable sources considered are solar, wind, nuclear, hydroelectricity and geothermal energy. MS Excel is used to model the effects of these scenarios on the electricity sector and results are presented.

Nicholas Cockran

Supervisor: Thomas Bräunl

Motor control and regenerative braking on the electric Lotus Elise

Electric drive systems is a technology that is set to revolutionise personal transportation. New developments in the fields of battery technology, electric motors and electronics make electric cars, for the first time, a viable alternative to internal combustion driven vehicles. The REV project group has a number of converted electric vehicles, among them a converted Lotus Elise. The purpose of the Lotus Elise conversion is, among other things, to improve the public perception of electric vehicles. It must be shown that electric vehicles can have a driving range necessary for everyday usage.

The work of this thesis is first and foremost on implementing regenerative braking on the Lotus Elise and demonstrating its effectiveness. It also investigates different control methods for the cars motor controller. Properly implemented regenerative braking can boost the range of an electric vehicle without the need for extra batteries and, hence, additional weight. Discussed are a number of alternative methods for implementing regenerative braking as well as discussion on the application of super-capacitors in regenerative braking systems.

Michael Gadecki

Supervisor: Jasmine Henry

Automation of the Electrical Booster in Solar Thermal Water Heaters

With the rising cost of electricity and increasing urgency for households to become environmentally sustainable, households are in many cases replacing their existing electrical hot water systems with solar thermal water heaters (STWH), many of which have an electrical booster. STWH with electrical boosters can reduce electrical energy consumption and green house gas emissions by up to 50 to 90 per cent, compared to conventional electrical water heaters. However, if the user of the STWH wants hot water on demand, such reductions in electrical energy may not be achievable, due to the nature of manual or semi-automated electrical booster controller.

The purpose of this project was to design and implement a prototype control system that regulates the electrical booster more effectively and efficiently than current control systems. To achieve this goal, a microcontroller circuit was built and programmed to calculate the time it will take for the water inside the STWH to reach the user's desired temperature. If the time calculated exceeded a set time period, the controller will automatically activate the booster.

Testing of the controller prototype was conducted in laboratory conditions, under varying light conditions, to determine its effectiveness at controlling the electrical booster. The test results show that the controller is able to calculate the heating time within seven degrees of accuracy. To determine if the controller is more efficient than current control systems, additional testing is required.

Karri Harper-Meredith

Supervisor: Thomas Bräunl

The Engine Audio Replication System and The Renewable Energy Vehicle Project

Regardless of how they are implemented, it is becoming increasingly clear that electric motors will be a significant part of our transport future. We are likely to see an increase in the number of electric vehicles whether they are coupled with ICEs or are supplied with power from batteries alone. If electric cars are to become common then it is essential that their problems and disadvantages are addressed. One such problem is the lack of noise that is produced at low speed by this type of vehicle. Their quietness can pose a significant risk to pedestrians, especially those who are visually impaired. This project was undertaken to provide a solution to this problem by applying electrical engineering knowledge gained through undergraduate study at the University of Western Australia.

The Engine Audio Replication System is an engine sound recreation system under development as part of the Renewable Energy Project, based at the University of Western Australia. Using software developed by a previous student, and a hardware support system created for this project, EARS is capable of reproducing the sound of any vehicle. EARS was first developed for use in the REV project's electric Lotus Elise, a sports car which had limited room for hardware installation, making the design and implementation of EARS even more challenging.

The software, Ferrari on a Stick (FoaS), was developed by Chriss Hellsten in 2009. It uses speed and acceleration signals to simulate the noise of an internal combustion engine (ICE). The noise is then amplified and projected outside the car. The software itself can be run on most computer hardware. For the purpose of testing, a PC was used, but the software is inthe process of being adapted for use with a microcontroller.

The result is a reasonably priced system which provides an appropriate level of warning to pedestrians. EARS will allow the electric car of the future to be driven with reduced risk of injury caused by low speed collision.

Daniel Harris

Supervisors: Nathan Scott, Thomas Bräunl

REV SAE Front Drive

The aim of this project was to design a front wheel drive system for a formula SAE electric car. In doing this, the project aimed to promote electric cars, further the technology involved and eventually produce a car for competition. This was achieved firstly by identifying possible design paths based on the given constraints. These were evaluated and an in-wheel design consisting of a motor in series with a gearbox was chosen. This was then modelled in SolidWorks and tested in COSMOS. After the computer modelling was finalised construction of the proposed design commenced.

Aaron Knight

Supervisor: Jasmine Henry

Energy studies of flat pack housing for Perenjori

Transportable housing is used in regional Australia to provide affordable accommodation in mining and agricultural communities. Many typical transportable housing designs are optimised for cost of construction rather than energy efficiency. The Advanced Timber Concepts (ATC) Research Centre of Western Australia has developed a flat pack housing design optimised for energy efficiency. An energy study is performed on a prototype of the new design, constructed in the Western Australian wheat belt town of Perenjori. An experimental method is developed to determine heating and cooling degree-hours. Degree-hour values can be used to compare energy efficiency of building designs.

Residential buildings consume 24% of the total electrical energy produced in Australia. A large percentage of this energy is used for heating and cooling. This report discusses concepts which aim to improve the energy efficiency of building designs. Transportable housing is often constructed in areas with limited power availability. Autonomous energy systems are discussed which are suitable for small accommodation facilities located in Mid Western Australia. The application of a renewable energy hybrid power system is proposed.

Jonathan Oakley

Supervisor: Thomas Bräunl

Evaluating Electric Vehicles

Conventional road transport is powered by non-renewable hydrocarbon fuels and is a major contributor to green house gas emissions. These factors have raised global interest in electric alternatives. Several large manufacturers are starting production of completely electric cars. Currently the performance and range of these vehicles is measured using standardised tests. These methods have been adapted from the speed profile testing used to measure fuel economy and emission levels in internal combustion powered vehicles. Research suggests that such testing does not accurately describe economy or emissions in real driving conditions. The aim of this project was to assess the performance of the electric vehicles produced by the Renewable Energy Vehicle project by conducting the standardised tests and comparing them to real world driving conditions. Real world testing under a variety of conditions was completed. Some speed profile testing was completed on a test track and chassis dynamometer. The results from speed profile testing suggest that the standardised tests are overestimating energy consumption. The real world results have shown large energy consumption increases for accessory usage and high traffic scenarios that are not tested using standard procedures.

Alexander Ottenhoff

Supervisor: Christopher Harris

Gridding for Radio Astronomy on Commodity Graphics Hardware Using OpenCL

With the emergence of large radiotelescope arrays such as MWA, ASKAP and SKA the rate at which data is generated is nearing the limits of what can currently be processed or stored in real-time. Since processor clock-rates have plateaued computer hardware manufacturers are trying different strategies, such as developing massively parallel architectures, in order to create more powerful processors. A major challenge in high performance computing is the development of parallel programs which can take advantage of new processors. Due to their extremely high instruction throughput and low power consumption, fully programmable Graphics Processing Units (GPUs) are an ideal target for radio-astronomy applications.

This research investigates gridding, a very time-consuming stage of the radioastronomy image synthesis process, and the challenges involved in devising and implementing a parallel gridding kernel optimised for programmable GPUs using OpenCL. A parallel gridding implementation was developed which successfully outperformed a reference single threaded gridding program in all but the smallest test cases.

John Pearce

Supervisor: Thomas Bräunl

Electric Vehicle Telemetry

In early March the Western Australian electric vehicle state trial was launched comprising ten converted electric cars. These cars are being used as regular fleet vehicles in various companies and government departments over a period of two years. To be able to effectively research the impact these cars have within a fleet and upon their drivers a system to remotely monitor the cars has been developed.

Based upon GSM and GPRS technologies the system is able to monitor the car's status, from whether the headlights are being used to when, where and how much power is being used to charge the car. Detailed and summary statistical information is then able to be made instantly available to researchers. The first of these cars is currently in the final stages of completion.

Nicholas Randell

Supervisors: Nathan Scott, Thomas Bräunl

Design and Implementation of a Motor Drive for Steering a BMW X5 Vehicle

This project has been commissioned by the UWA Renewable Energy Vehicle (REV) team to aid in their ongoing research into intelligent automotive control. These systems have the aim of improving vehicle safety, a vital field of research. The project aims to deliver electronic actuation of the steering system of a research vehicle. A review of available literature concluded that limited documentation detailing methods of after-market steering actuation was available.

Alternative methods of actuation were assessed against a design brief. Actuation by a DC motor mounted in the engine bay with a belt drive to the steering column was deemed to be the most suitable approach. The design requirements of necessary components were evaluated in detail allowing components to be analysed and refined until final designs were produced. A motor constraint and thermal barrier were required, and were integrated into a single aluminium component folded from 1.5mm sheet metal. Both the steering column and a timing pulley were modified to allow the pulley to be attached directly to the steering column.

The system was successfully installed in the vehicle and tested under experimental conditions. The system satisfied most of the design requirements. Vehicle steering was actuated at an effective rate without the introduction of any significant safety hazards. Convenience of the car was unaffected by modifications made. There exists significant scope for future work on the project. The system requires both a method of detecting driver override and the installation of feedback sensors to be developed further.

Stephen Wilkins

Supervisor: Jasmine Henry

IDEAL House: Weather Station Design, Implementation and Monitoring – A Walk-through from Selection to Calibration

As the world focuses on climate change, sustainability is becoming a key part of the strategy to reduce greenhouse gas emissions. This new focus has initiated projects such as the IDEAL (Intelligently Designed Engineering for Advanced Living) House that commenced in 2005 by the school of Electrical, Electronic and Computer Engineering at the University of Western Australia (UWA). The IDEAL House aims to showcase state-of-the-art technologies and practices in sustainability, automation and control. With the use of these technologies and practices, it is intended to provide comfortable living while still retaining energy efficiency and sustainability.

The IDEAL House test facility is physically located in the Engineering car park of UWA and acts as a test bed for technologies before implementation on a larger scale elsewhere. For example, the IDEAL Farmhouse located on the Ridgefield Future Farm in Pingelly.

The project's aim is to design and install a suitable apparatus to collect weather data. The weather data is to be displayed in real-time via a website for wider access to external parties.

Real-time access to this weather information will allow the data to be used as an input for control of other appliances located inside the IDEAL House (e.g. a fan). Once these aims have been successfully fulfilled at the test facility at UWA, the knowledge acquired will then be used to propose a suitable system for the Pingelly IDEAL Farmhouse.

Tim Yates

Supervisor: Thomas Bräunl

Robot Hardware Design Decisions for the MAGIC 2010 Competition

This thesis discusses the procedure undertaken to construct a chassis, choose instruments and connect instruments to a number of robot bases, with the goal of creating a team of surveying robots. The function of the robots is to autonomously survey an urban environment safely while avoiding hostile objects, with the goal of competing in the MAGIC 2010 competition, which is was held by the Australian and US Departments of Defence in November 2010.

The focus of the competition is on developing the state of the art of autonomous robots, and specifically on the development of pathfinding and decision making processes. However, in order for these goals to be realized, the physical aspects of the robot must be sound.

The focus will be on the hardware design decisions made, including the selection of components and their importance within the scope of the competition, the revisions to the design of the robot made after a preliminary test was passed in June, and design changes made after the June test as new components were added to the robot to improve its efficacy.

The final design is included in this document and discussion of the design aspects that were fulfilled. This design has been successfully replicated for seven robots and has enabled the programming goals of the team to be realized effectively.

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