ANNUAL REPORT 2005

School of Electrical, Electronic and Computer Engineering
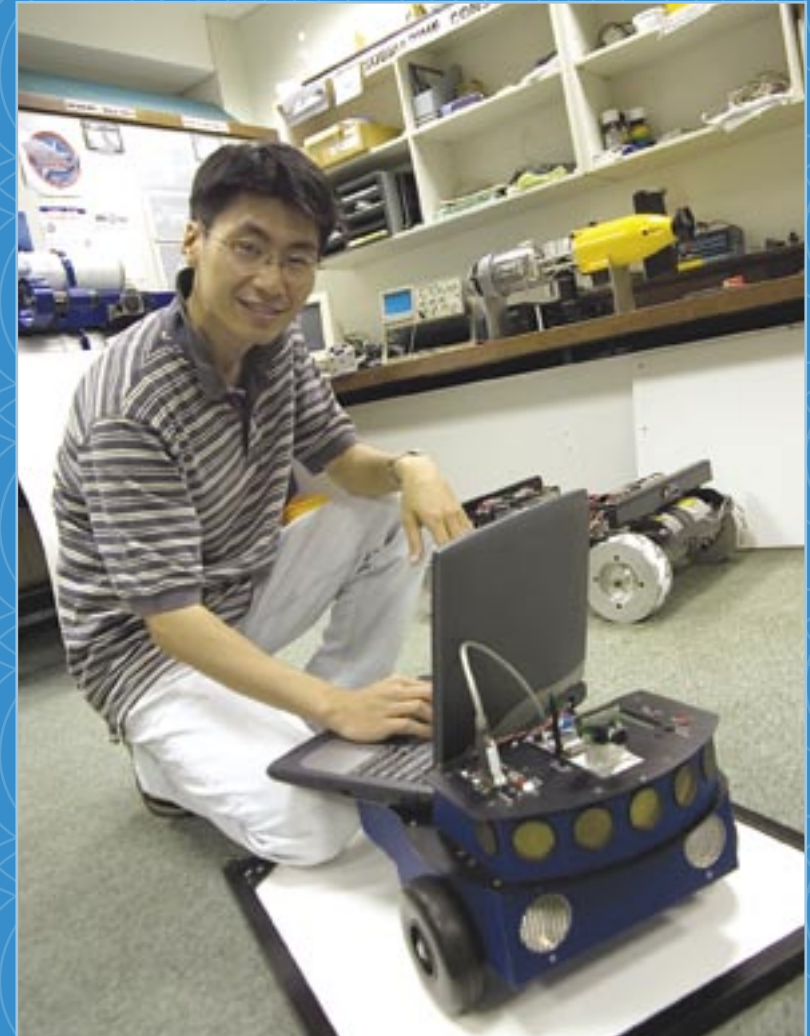
THE UNIVERSITY OF WESTERN AUSTRALIA

CIIPS

Centre for Intelligent Information Processing Systems

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THE UNIVERSITY OF WESTERN AUSTRALIA

CONTENTS

DIRECTOR'S REPORT 2005

The year 2005 was again a very productive and a very busy year at CIIPS. We hosted a number of international visitors that came to us with fresh ideas and participated in several research projects from The University of Manitoba, Canada, Hokkaido University Japan, University Paderborn, University Kaiserlautern, FH Koblenz, FH Giessen, Technical University of München and Technical University of Ilmenau, Germany. We will continue with our mutual beneficial exchange programme and are looking forward to meeting our 2006 visitors.

The Genesis project has been resurrected in 2005, which provides a link between the School (and especially the IT Programme) and High Schools all over the country, by providing a number of hands-on electronics projects. Programme terms and individual project details can be seen at http://genesis. ee.uwa.edu.au .

The introduction of the degree programme in Process Instrumentation and Control will hopefully increase student numbers for the School, while EE and IT enrolment numbers are still trailing Mechanical and Mechatronics Engineering. Another effort is the re-introduction of a Computer Engineering stream in the final year of the EE programme, which is likely to start in 2007. The nationwide downturn in IT / Computer Systems is expected to be reversed by 2007 as new job opportunities open up in Australia and world wide, so hopefully, this will bring back student numbers to the year 2000 level.

CIIPS continues to play an important role in the IT education of all engineers at UWA and is a significant partner for research in academia and industry.

Thomas Bräunl

Director
Centre for Intelligent Information Processing Systems

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.

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 spoken language 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.

Over the past five years, the Centre has attracted grants and contracts totalling more than $2.0 million from the Australian Research Council ($665,000), the Defence Science and Technology Organisation ($110,000), and other bodies.

EQUIPMENT

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

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

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.

MEMBERS OF THE CENTRE

ACADEMIC STAFF

School of Electrical, Electronic and Computer Engineering

Associate Professor Thomas Bräunl,
Dipl.-Inform., MS, PhD, Habil., MIEEE, MDHV

Associate Professor Gary Bundell,
BE, MEngSc, PhD, MIEAust, CPEng, MIEEE, MIEE, CEng

Dr Tyrone Fernando,
BE(Hons), PhD

Dr Roberto Togneri,
BE(Hons), PhD, MIEEE

Mr Terry Woodings,
BSc, DipComp, FACS, FQSA

Adjunct Appointments

Dr Ramachandran Chandrasekhar,
BE, PhD, MASc, MIEEE

Associate Professor Anthony Zaknich,
BE, MESc, PhD, BSc, BA, SMIEEE, MAES

Associate Professor John Morris,
BSc(Hons), PhD

School of Mathematics and Statistics

Dr Mike Alder,
BSc(Hons), ARCS, PhD, MEngSc, MIEEE

STAFF

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Artifical Neural Nets; Computer Mediated Education; Pattern Recognition

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Administrative Assistant; CIIPS Secretary

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Speech and Audio Processing, Spoken Language Systems, Multimodal Recognition

Woodings, Terry
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Software Engineering, Software Metrics

Zaknich, Anthony
tonko@ee.uwa.edu.au ....Room 4.16
Artificial Neural Nets; Signal Processing and Pattern Recognition

VISITORS

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Tobias Bielohlawek
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Annika Kuhl
TU Ilmenau, Germany

Kalle Ohlsson
Chalmers University of Technology, Sweden

Thorsten Ruehl
FH Giessen, Germany

Christian Schmitz
FH Koblenz, Germany

POSTGRADUATE STUDENTS

Doctor of Philosophy

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

Mr Adrian Boeing
Genetic Algorithms (T.Bräunl)

Mr Oscar Chan
Prosody for Language Modelling (R.Togneri)

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

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

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

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

Mr Peyman Kouchakpour
Genetic Programming (A.Zaknich/T.Bräunl)

Mr James Ng
Path Planning (T.Bräunl)

Mr Alistair Sutherland
Bipedal Locomotion (T.Bräunl)

Mr Aik Ming Toh
Speech Recognition in Hostile Environments (R.Togneri)

Mr Terry Woodings
Variation in Project Parameters as a Measure of Improvement in Software
Process Control (G.Bundell)

Mr Azman Muhamed Yusof
Vision Tracking (T.Bräunl)

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

Master of Engineering

Miss Mahsa Mooranian
My Crystal Diary (G.Bundell)

Mr Marco Kuhne
Phoneme Recognition (R.Togneri)

UNDERGRADUATE STUDENTS

Rajan Aggarwal	Navid Nikraz
Elliot Alfirevich	Sonya Ong
Philip Bastian	Selina Peng
Evan Broadway	Nora Pribadi
Fook Seng (Williams) Chin	Siaw Gaan Sia
Winston Cheng	Gavin Sit
Jonathan De Lima	Stancho Stanev
James Devenish	Anthony Sugiono
Chong Kien Gan	Rama Riansyah Syahrul
Keat Neng Gan	Choon-Lee Tan
Robert Hepburn	Damien Tang
Yuma Iwasaki	Zhi Wen Tay
Kok Wee (Sean) Kho	Jack Lyle Thompson
Sarah Catherine Khouri	Chris Thorp
Ga Rick Lee	Chung-Yuan(Johnny) Wang
Leonard Lee	Rafic Waters
Kasun Liyanaarachchi	David Wells
Erni Moen Kasir	Stephen Whitely
Andy Ng	William Jiin-Jang Wong
Mur Chun Ng	Wing Fong Wong

GROUP PHOTO

6th row, left to right: Kalle Ohlsson, Choon-Lee Tan, Sonya Ong, Jonathan De Lima, Damien Tang, Selina Peng, Aaron Cha

5th row, left to right: Bernhard Gerl, Marco Kuhne, Serajul Haque, Azman Muhamed Yusof, Jack Lyle Thompson, Chang Su Lee, Tobias Bielohlawek, Thorsten Ruhl, Weiqun Zheng

4th row, left to right: Mahsa Mooranian, Oscar Chan, Aik Ming Toh, Navid Nikraz, Stancho Stanev, David Wells, Chris Thorp, Gustav Friberg

3th row, left to right: Robert Hepburn, James Devenish, Yuma Iwasaki, Kasun Liyanaarachchi, Will Chin, Sean Kho, Leonard Lee

2nd row, left to right: Sarah Khouri, Elliot Alfirevich, Philip Bastian, Hiroyuki Harada, Adrian Boeing, Michael Drtil, Yves Hwang

Front row, left to right: Roberto Togneri, Sandra Snook, Thomas Bräunl

RESEARCH ACTIVITIES

1. Hardware Design Lab (Associate Professor J. Morris)

The Hardware Design Lab works on hardware and software of concurrent systems, reconfigurable hardware, and fast interconnect networks.

Environmental protection has turned the hardware design laboratory into a pure software operation for 2005. Doppler LIDAR systems can be used to measure wind fields over an area of several square kilometres and thus provide valuable input for monitoring and predicting pollution dispersion, bushfire progression and meteorogical studies. A new algorithm for extracting information from inherently ambiguous LIDAR scans was developed and tested. The group will return to hardware next year when some LIDAR equipment arrives in Western Australia.

2. Information and Software Engineering Research Group
(Associate Professor G.A. Bundell and Mr T. Woodings)

The aim of the Group is to engage in research into the engineering of large-scale information and software systems. This means 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.

Distributed information and software and engineering projects in the area of benchmarking distributed object infrastructures was further extended in the last year with updated technology comparison projects on CORBA, Jini and .NET technologies over a range of platforms and client/server configurations. A specific focus this year has been in real-time CORBA.

An ongoing area of development has been in technology evaluations of various mobile information appliance platforms, ranging from 3G cellular handsets to enhanced PDAs. Detailed work focused on performance assessment of various types of hardware and software emulation environments. An industry sponsored project into a low-cost inertial navigation system for mining applications was also initiated.

Postgraduate research in automated software generation from UML specifications was carried further and work linking component design information to earlier work on software component testing was progressed. An active area of on-going interest is application of design patterns to the development of high-performance mobile information devices.

Other research undertaken in the software engineering area was a continuation of an investigation into software project and process metrics and their effectiveness. Industry case studies were explored to further develop estimation toolkits that project managers can use to determine the suitability of various metrics for use in software project monitoring and control.

3. Integrated Sensory Intelligent Systems Lab
(Associate 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 systems.
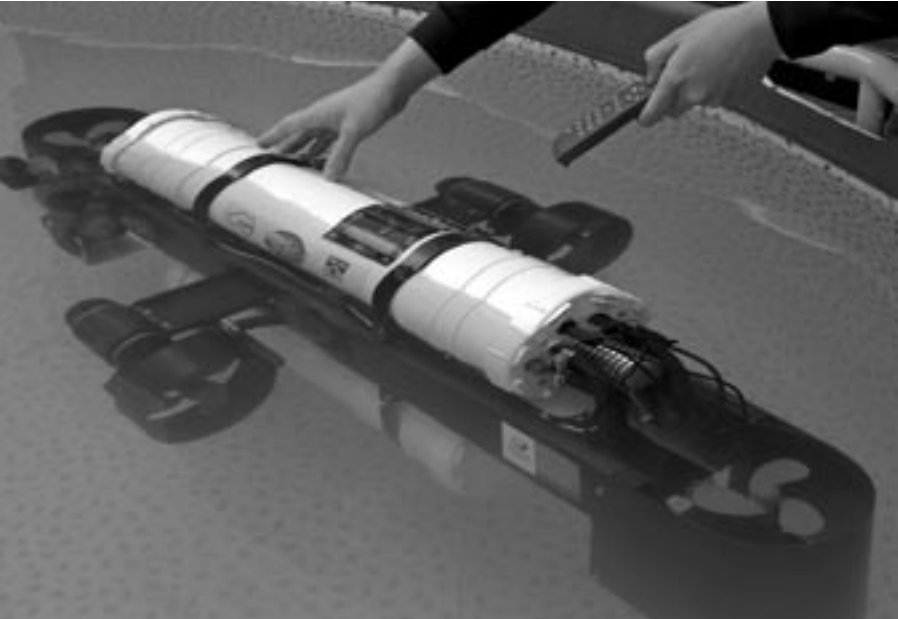

Projects over 2005 were mainly related to the development of DSP hardware and related software and algorithms for loudspeaker frequency response testing along with associated filter and systems design and testing. This work is the initial contribution toward the production of a research monograph, working title: Zaknich, A., "Loudspeaker response testing, under relaxed anechoic conditions."

4. Mobile Robot Lab (Associate Professor T. Bräunl)

The Mobile Robot Lab has been established since 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

The autonomous underwater project was the major project conducted in the Mobile Robot Lab in 2005. The Mako AUV (Autonomous Underwater Vehicle) has been fitted with sonar sensors and pressure sensors and new control and communication software has been implemented. It is now possible to send commands from a Bluetooth-enabled mobile phone to the AUV (when surfacing). A second AUV based on the much smaller and simpler USAL shell has been designed and constructed, while software development and testing will take up the first half of 2006. The first version of the SubSim simulation system had been released in January 2005, while the second extended version followed in September 2005. The third version of SubSim together with an even more general simulation engine that could be used for other robots as well, is planned for mid-2006.

The second major project in 2005 was the completion of the Omni-directional vehicle platform. Built by the EECE workshops and using four powerful motors from decommissioned wheelchairs, the robot has a payload of 100kg and can easily carry a person. Its four driven wheels have been designed using the Mecanum principle: a number of free rolling barrels along the surface of the wheel allow the vehicle to drive in any direction (forward/backwards/sideways) and turn on the spot, very similar to a hovercraft.

The vehicle has been fitted with infrared distance sensors and shaft encoders. The addition of a proper chair, 6D input device and a software user interface is planned for 2006.

In the year 2005, the Mobile Robot Lab had a number of visitors:

Prof. Hiroyuki HARADA
Hokkaido University, Japan

Prof. Jacky BALTES
Uni. of Manitoba, Winnipeg, Canada

Dr. Heiko KALTE
Univ. Paderborn, Germany

Christian SCHMITZ
FH Koblenz, Germany

Michael DRTIL
FH Koblenz, Germany

Thorsten RUEHL
FH Giessen, Germany

Tobias BIELOHLAWEK
Univ. Kaiserslautern, Germany

Jan HAAS
Univ. Kaiserslautern, Germany

Annika KUHL
TU Ilmenau, Germany

Bernhard GERL
TU München, Germany

5. Signals and Information Processing Lab (Dr R. Togneri)

The Signals and Information Processing Lab works in the area of spoken language systems and also in related areas of signals and information processing: speech/music synthesis, software tools for speech, textual data and language processing, audio-visual speech and pattern recognition.

In 2005 a range of final-year projects were undertaken in the area of signal processing, speech recognition, image processing and information processing. Successful first-class honours projects included:

(1) Multimodal User Authentication fusing both face recognition and speaker recognition technologies.

(2) Implementation and evaluation of a Linear Dynamic Model (LDM) for dynamic acoustic modelling.

A full-time Masters project commenced in 2005. Marco Kuhne commenced his research in February on "Wavelet Features for Phoneme Recognition". Marco joins the existing PhD students who worked full-time throughout 2005: Aik Ming Toh, Oscar Chan and Serajul Haque, and the part-time PhD student: Dariush Farrokhi.

In 2005 the NICTA sponsored LaMP (Last Meter Problem) project with WATRI commenced with Roberto Togneri being appointed as the team leader for the Speech Technology group. Aik Ming Toh will be one of the students contributing to the LaMP project. Marco Kuhne has also expressed an interest to extend his Masters to a PhD and if so would also be contributing to the LaMP project. Collaboration between the SIP Group and Professor Li Deng from Microsoft Research, Redmond, USA also resulted in the acceptance for publication of a regular article in the journal Speech Communication.

Dr. Jae Ha Yoo has been invited to visit the SIP Group in 2006. His area of interest is in Speech Enhancement.

6. Systems and Biomedical Engineering Lab (Dr T. Fernando)

The Systems and Biomedical Engineering Lab works on a number of projects on Electronic Medical Systems and general Signal Processing Systems.

The following projects were undertaken in the area of Systems and Biomedical Engineering within CIIPS. The projects were carried out by staff, students enrolled in PhD and also final year Engineering students.

Functional Observers

The design of minimum order linear functional observers has been an open problem for the past four decades. One of the key research contributions in this group has been in presenting a solution to this long outstanding problem.

Two-Dimensional Systems Theory and Applications

Systems that process two-dimensional (2-D) signals, eg. image intensity, are 2-D systems. Such systems have wide applications in manufacturing, telecommunications, defence and IT. The stability test of 2-D systems and super-resolution spectral estimation of 2-D signals are two of the most important problems that limit further development of 2-D systems. This project aims at developing efficient stability test and super-resolution spectral estimation algorithms for 2-D systems and signals.

Robust Control and Filtering For Uncertain Systems

Feedback control systems are widely used in manufacturing, mining, automobile and military hardware applications. It plays a key role for maintaining efficiency, reliability and profitability. In response to these demands, control systems are being required to deliver more accurate and better overall performance in the face of difficult and changing operating conditions.

Design of Reduced-Order Observers to Estimate States and Unknown Inputs of Nonlinear Systems

This project addresses the problem of designing an asymptotic observer to estimate both the states and the unknown inputs of nonlinear systems. This project has numerous applications in the areas of fault-detection and control, secure communications and conditions monitoring systems. By adopting the generalized state-space model, it is shown that it is possible to simultaneously estimate both states and unknown inputs and that the error converges asymptotically to zeros with any prescribed rate.

Reduced Order Observers Theory

This project solves the problem of designing reduced-order observers to estimate a linear functional of the state vector of complex, large-scale systems. The project will attempt to answer some fundamental questions such as: Given a complex, large-scale system: (i) what is the minimum order of the observer? (ii) Can the minimum order be pre-determined? And (iii) Can the minimum-order observer be systematically designed? This project has many applications in the areas of fault-detection and control, secure communications and in-process monitoring.

Closed Loop Control of Blood Carbon Dioxide and Oxygen Tension

A majority of critically ill patients require the assistance of a mechanical ventilator to maintain arterial carbon dioxide and oxygen tension within clinically acceptable levels. A mechanical ventilator can alter breath parameters in order to maintain a patient in a clinically stable state. Breath parameters that can alter arterial carbon dioxide tension are tidal volume and respiratory rate whereas oxygen tension can be altered by positive end expiratory pressure and oxygen fraction in inspired air. In a mechanical ventilator all these four breath parameters can be altered manually or from an external computer. Developing a closed loop system to regulate blood gas tensions can relieve the clinical staff from routine repetitive tasks associated with ventilator management.

Blood Glucose Regulation in Diabetics

The Diabetes Control and Complications Trial conducted by the National Institute of Diabetes and Digestive and Kidney Diseases showed that keeping blood sugar levels as close to normal as possible, leads to a substantial decrease in long-term complications of diabetes. The goal of diabetes treatment is to control blood glucose to levels that are as near normal as possible, in order to reduce the risk of disease complications.

Pain Management of Postoperative Patients - Patient Controlled Analgesia

Patient Controlled Analgesia refers to a way of pain management by self administering drugs. Pain is subjective and a feedback system to manage pain should incorporate pain intensity felt by the patient. A current method of pain management is through a bolus infusion of analgesic when pain is felt by the patient with no consideration to the intensity of pain being felt. This project aims at developing a closed loop system for pain management based on the intensity of the pain being felt and also using methodology to optimize the amount analgesic being delivered.

CIIPS PUBLICATIONS 2005

BOOKS

1. YANG, W.Y. , CAO, W. , CHUNG, T.S. , MORRIS, J.M.

   Applied Numerical Methods using MATLAB,

   New Jersey, John Wiley and Sons., 2005

2. ZAKNICH, A.

   Principles of adaptive filters and self-learning systems,

   Springer-Verlag, Series on Advanced Textbooks in Control and Signal Processing, July 2005, ISBN 1-85233-984-5

BOOK CHAPTER

MORRIS, J., LEE, K., KIM, J.

Cilk Versus MPI: Comparing Two Parallel Programming Styles on Heterogenous Systems

In:Laurence T. Yang, Minyi Guo (Ed.), High-Performance Computing : Paradigm and Infrastructure., New York, John Wiley and Sons., p.51-65, 2005

JOURNAL ARTICLE

CHEE, F., SAVKIN, A.V., FERNANDO, T.L., AND NAHAVANDI, S.

Optimal H-infinity Insulin Injection Control for Blood Glucose Regulation in Diabetic Patients

IEEE Transactions On Biomedical Engineering, Vol.52, No.10, p.1625-1631 October 2005

MAGAZINE ARTICLE

BRÄUNL, T., KOESTLER, A., WAGGERSHAUSER, A.

Mobile Robots between Simulation & Reality,

Servo Magazine, vol. 3, no. 1, Jan. 2005, p.43-50 (8)

CONFERENCE PAPERS

1. BOEING, A., BRÄUNL, T.

   SubSim: An autonomous underwater vehicle simulation package,

   International Symposium on Autonomous Minirobots for Research and Edutainment, AMiRE 2005, September 2005, Fukui, Japan, p.33-38 (6)

2. DELMAS, P.J., GIMEL'FARB, G., LIU, J. ,MORRIS, J.

   Concurrent stereo matching: An image noise-driven paradigm,

   Mexican International Conference on Artificial Intelligence, Proc. of MICAI, 3789, Monterrey, Nuevo Leon, Mexico, November 14 - 18, 2005, p.307-317

3. GIMEL'FARB, G., MORRIS, J., DELMAS, P.J., LIU, J.

   Noise-driven symmetric concurrent stereo matching,

   Image and Vision Computing New Zealand Conference (IVCNZ 2005), Proc. of IVCNZ, Dunedin, New Zealand, November 28-29, 2005, p.90-95

4. HAQUE, S., TOGNERI, R., AND ZAKNICH, A.

   A zero-crossing perceptual model for robust speech recognition,

   Inter-University Postgraduate Electrical Engineering Symposium, Curtin University, Perth, Western Australia, 27th September 2005.

5. LIU, J., DELMAS, P.J., GIMEL'FARB, G., MORRIS, J.

   Stereo reconstruction using an image noise model,

   Conference on Digital Image Computing: Techniques and Applications, Proc. of DICTA, Cairns, Australia, December 6th-8th, 2005.

6. MORRIS, J.

   Algorithm Animation: Using the Algorithm Code to Drive the Animation,

   The Australasian Computing Education Conference (ACE), AYoung(ed.), Proc of the Australasian Computing Education Conference (ACE), Newcastle, NSW, January 31 - February 3, 2005, p.85-92

7. MORRIS, J.M., GIMEL'FARB, G., LIU, J., DELMAS, P.J.

   Concurrent Stereo Matching: An Image Noise-Driven Model,

   5th International Workshop on Energy Minimization Methods in Computer Vision and Pattern Recognition, Rangarajan, A., Vemuri, B., Yuille, A.L.(ed.), Proc. 5th International Workshop on Energy Minimization Methods in Computer Vision and Pattern Recog, 3757, St Augustine, Florida, November 9-11, 2005, p.46-59

8. TOH, A.M., TOGNERI, R., NORDHOLM, S.

   Investigation of Robust Features for Speech Recognition in Hostile Environments,
   Proceedings of APCC2005, October 2005, Perth, Australia, p.956-960.

CONFERENCE PROGRAM COMMITTEES AND CHAIRS

Associate Professor T. Bräunl

- International Symposium on Autonomous Minirobots for Research and Edutainment (AMiRE), 20-22 September 2005, Fukui, Japan

- Mascots 2005, 26-30 September 2005, Atlanta, USA

- IASTED International Conference on Robotics and Applications (RA 2005), 31 October - 2 November. 2005, Cambridge, US

- Third International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS 2005), 13-16 December 2005, Singapore

ABSTRACTS OF FINAL YEAR PROJECT REPORTS

PHILIP BASTIAN
Controlling a Biped Robot Using Digital Servos
(Supervisor : Associate Professor T. Bräunl)

In a world where the use of robots in the home is becoming ever more likely, research into humanoid robots has become more widespread. The University of Western Australia has worked on several such robots in the past, all relying on analogue servos to move the joints. The latest robot, codenamed Andy Droid 2, utilises digital servos that have many advantages over their analogue predecessors, not the least of which is the ability to receive feedback on their actual position and the amount of additional current being applied to move or return the servo to the required position.

In this year's project, work was done to determine whether a control system could be constructed to allow the robot to walk without traditional feedback sensors, i.e. using only the feedback from the digital servos. A static control system was developed which proved ineffectual due to the low sensitivity of the feedback. Also, several manually programmed gaits were developed and, once stable, their feedback graphs were examined to further refine the gait.

FOOK SENG (WILLIAMS) CHIN
Automated Home
(Supervisor : Dr T. Fernando)

In today's modern environment, there is heavy reliance on the sense of sight to accomplish day-to-day activities. Unfortunately, those who are blind struggle to cope, especially in finding work. It is fortunate that the development of technology has made it possible to gain employment which were previously inaccessible to them before. An example of this is of the role of the office secretary or receptionist. Through the use of technology such as computers that can convert the text on the screen to audio through a headset and the use of specially designed telephone switchboard, blind people are able to adequately perform the job.

It is required that the computer program and telephone work concurrently with each other as information is often relayed to a client on the phone from the computer. However, this can cause inconvenience to the user who will need to switch between both headsets. Furthermore if the user is using one of these devices, they would be oblivious to visitors trying to approach them. Therefore, the motivation of this project is to start on the development of a headset which would eliminate these problems and would ultimately improve the ability of a blind person to work in a office secretary or receptionist role.

The goal of this thesis is to focus on the design aspect of the environmental awareness audio component of the system. More specifically, the research conducted studies the components of gain control and noise reduction, which is critical to the system. Future commercial implementation of the design would increase the user's awareness when being approached by visitors.

To achieve this objective, possible algorithms and techniques that could achieve the desired tasks were identified. MATLAB was then used simulate these algorithms to determine its suitability for the system. The culmination of this thesis is a design using an Automatic Gain Control algorithm, a band pass filter and an adaptive filter to make speech from a visitor audible even when the secretary or receptionist is engaged with the aforementioned devices. From this design, an implementation onto a digital signal processor is possible. With further development, a prototype of this device can be created which could improve a blind person's role as a secretary or receptionist.

ROBERT HEPBURN

A Comparison of Existing Methods for the Design of Functional Observers

(Supervisor : Dr T. Fernando)

Since David Luenberger's introduction of Observers in his paper "Observers for Multivariable Systems" in 1966, the methods for designing, simplifying and optimising observers has been an open topic in the literature. One particular case of interest is Functional Observers. It is often the case that we require some linear combination of the state variables to provide the system feedback in a control application (for example, Linear Quadratic Regulators) and for this purpose functional observers were designed. Rather than reconstructing each of the state variables we can instead construct a linear combination of them with the desired result and at a much reduced order.

In this paper we provide a survey of the literature surrounding the design and implementation of functional observers from 1966 to the present. The survey will include definitions of the relevant theories used by the authors and we hope to standardize the notation used in various papers. The major works in the topic will be presented and analysed including numerical examples where possible and comparisons to previous and / or current methods.

YUMA IWASAKI

Omni-Directional Wheelchair

(Supervisor : Associate Professor T. Bräunl)

The University of Western Australia Centre for Intelligent Information Processing Systems (CIIPS) has been developing an Omni-Directional Wheelchair since 2004. The Omni-Wheelchair uses Mecanum wheels, which allows for three degrees of freedom mobility. The Mecanum wheel consists of a central driven hub with free rollers mounted on its circumference at 45 degrees to the wheel axis. Possessing an extra degree of freedom compared to conventional wheelchairs in an Omni-Wheelchair would be of great benefit to the user, especially in tight compact home environment. Low-level motion software was written using C, which allows for infra-red remote control of the vehicle's direction and power to the motors. A mechanical mouse was modified to a prototype encoder and will give the vehicle feedback of its wheels' angle and velocity. This thesis hopes to set up the foundation for higher level of motion and completion of the Omni-Wheelchair.

KOK WEE (SEAN) KHO
Robust Feature Extraction
(Supervisor : Dr R. Togneri)

This thesis presents an investigation on robust features for speech recognition. Most current speech recognition systems are based on Hidden Markov Models, or HMM's, and the assumption that within each state, speech features are independent and identically distributed (IID), causing rapid deterioration in performance of the system in noisy conditions. One way of overcoming this is to include temporal characteristics in the speech feature. The use of Cepstral-Time Matrices or CTMs as a means to include temporal characteristics and improve the recognition rate is explored. Results are presented for the CTM being tested against the widely accepted MFCCs, where it is shown that the CTM offers a higher performance rate. The features are also appended together, and results show a slightly higher performance rate compared to the CTM.

SARAH KHOURI
Automatic Speech Recognition Using Linear Dynamic Models
(Supervisor : Dr R. Togneri)

This dissertation aims to investigate a new type of approach to the problem of acoustic modelling for Automatic Speech Recognition (ASR) systems. The majority of current ASR systems rely on Hidden Markov Models, in which the output distribution corresponding to each state is modelled by a mixture of diagonal covariance Gaussians. Dynamic information is typically included by appending time-derivatives to feature vectors. Although this approach has proved successful, it makes false assumptions regarding the framewise independence of the augmented feature vectors and ignores the spatial correlations in the parameterised speech signal. Addressing these shortcomings is the motivation to explore the problem of acoustic modelling using instead a form of state-space model, the Linear Dynamic Model (LDM).

LDMs aim to characterise entire segments of speech rather than modelling individual frames of data. The segments that have been considered in this dissertation are phones. The continuous dynamical state of an LDM means that information is passed along the length of each segment, providing an explicit model of temporal correlation which is in contrast to frame-based models where the ordering of the data is ignored.

The TIMIT speech corpus is used as a base for speech classification experiments, tasks which are well suited to comparing modelling choices as they remove confounding sources of error associated with decoding or duration modelling. The goal is to determine whether this class of model is capable of producing comparable performance to that of current ASR systems when applied to the problem of acoustic modelling. For this reason, the classification accuracies obtained are compared against reported results for LDMs and also against benchmark accuracies from acoustic modelling systems using other model types.

SONYA ONG
Data Mining of Financial or Accounting Data
(Supervisor : Dr R. Togneri)

Portfolio management is a fundamental aspect of investment. This research presents the development of a data mining application using the concept of genetic algorithms in order to obtain useful information for making portfolio

investment decisions. Genetic algorithms are a versatile optimization techniques based on evolution, survival of the fittest and natural selection and are becoming increasingly common in the finance industry. Chromosomes are represented using simple moving averages of closing stock prices from a number of high-volume traded Australian Stock Exchange (ASX) listed stocks and fitness evaluation is based on a permutation of a buy or sell strategy determined by training the input data and the overall rate of return of the stock. Further comparisons are made with the use of exponential moving averages of closing stock prices.

SELINA PENG
Post-processing techniques for single-Doppler LIDAR data
(Supervisor : Associate Professor J. Morris)

Commercial-in-confidence.

CHOON LEE TAN
Benchmarking Mobile Device Emulators
(Supervisor : Associate Professor G. Bundell)

The mobile device emulator is a valuable tool provided by mobile device manufacturers to software developers to aid in the application development process. In the absence of an actual mobile device, a mobile device emulator recreates the user interface and behaviour of the device so that application development can still proceed. Software developers rely heavily on emulators to mimic the behaviour and to perform similarly to the device in order to gauge performance response times and anticipate implementation on the actual mobile device.

This project takes an in depth look at the performance of several mobile device emulators compared against the performance of actual mobile devices, through a process of performance analysis and benchmarking. The mobile device used throughout the project is the personal digital assistant (PDA), as they provide an ideal balance between a scaled mobile processor combined with a feature packed mobile operating system.

DAMIEN TANG

Modelling and Control of Insulin Delivery in Diabetes Treatment

(Supervisor : Dr T. Fernando)

A robust controller was designed within the framework of an automated closed loop insulin delivery system, using the H∞ mixed sensitivity approach. A simple linear mathematical model that was compatible with known physiological facts was used, with uncertainty characterised by $\pm 90\%$ variation in the model parameters.

Controller performance was assessed in terms of two criteria: its ability to tightly regulate blood glucose levels between 70–110 mg/dl (3.9–6.1 mmol/l) in response to an external glucose disturbance, and the ability of blood glucose levels to return to resting values within 180 minutes. The controller that was designed exhibited robust performance despite the presence of significant uncertainties in the model. For the worst-case combination of model parameters, the controller yielded a maximum blood glucose deviation of 8.5 mg/dl (0.47 mmol/l) and blood glucose returned close to its basal value within 100 minutes.

JACK THOMPSON

Musical Instrument Recognition

(Supervisor : Dr R. Togneri)

Traditional approaches to musical instrument recognition (MIR) have used artificial neural networks, nearest-neighbour classifiers or Gaussian mixture models for feature classification. This project investigated the performance of a hidden Markov model (HMM) classifier and mel-frequency cepstral coefficient (MFCC) features for MIR using 426 recordings comprising 3407 notes from 20 orchestral instruments. Models were trained for each instrument and these were used to transcribe 99 test sequences totalling 697 notes, with the recogniser simultaneously segmenting each recording and recognising the instrument playing each note.

Three performance metrics were used, namely the individual note classification accuracy (INCA), the recording transcription accuracy (RTA) and the recording classification accuracy (RCA).

The optimum system performance was achieved with a modified instrument set that consolidated the flutes and trombones to single instruments and divided each of the stringed instruments among two articulation styles. Using a 63 state L-R HMM, the optimum INCA (95.12%) and RTA (84.85%) were achieved using 13 MFCCs together with velocity and acceleration coefficients. The optimum RCA (98.99%) was obtained with 15 MFCCs together with velocity and acceleration coefficients.

These results show that HMMs are effective tools for MIR, though the use of recorded sequences of isolated notes in this study means that more work is required to construct a MIR system that can annotate or transcribe real performances.

CHRIS THORP
Control System for an Autonomous Underwater Vehicle
(Supervisor : Associate Professor T. Bräunl)

Autonomous underwater vehicles have become an active area of research and are beginning to find commercial acceptance. To be autonomous, AUV's rely heavily on sensors to navigate their environment using a variety of control systems.

This thesis develops a software control system for the University of Western Australia's Mako AUV. Beginning with low level motor control the thesis progresses towards the implementation of a of a PID tracking controller, providing a modular framework upon which depth and yaw proportional controllers are built with a view to their expansion to PID and PID tracking controllers. The second aspect of this thesis investigates the application of Bluetooth enabled portable devices as a bi-directional controller for use with an AUV.

Basic motor control is developed allowing a desired motor thrust to be delivered. Based on this, a modular control framework is developed implementing proportional control. Several experiments are undertaken to assess the system's performance and identify in-water aspects affecting the control of the Mako AUV.

Although restricted to use above water, Bluetooth wireless technology finds useful application as bi-directional remote control allowing instant feedback from an AUV. Software is subsequently developed to explore this application and its performance is assessed. Potential is identified for the extension of this software into a virtual remote display.

This thesis provides an effective basic motor controller and maneuver control system capable of depth and yaw control and a control device capable of acting as a remote display. It is hoped with the foundation this thesis provides that Project Mako finds itself well equipped for the challenges that lie ahead.

CHUNG-YUAN(JOHNNY) WANG
Patient Controlled Analgesia
(Supervisor : Dr T. Fernando)

The main objective of this project is to implement an observer structure for a circuit which exhibit a second order response system with the aid of a programmable logic controller (PLC). The main usage of the PLC in the industry is to compute the detected inputs, yield the programmed outputs, and feed back the programmed outputs to the system in order to control the system desirably. This project uses the advantage of PLC to read the input and the output from an RLC circuit, and subsequently compute these values as an observer in terms of control engineering concepts. The thesis will discuss on the background theories of implementing the observer, and also demonstrate how the programmable logic controller is applicable in this project.