THE NATIONAL UNIVERSITY
of SINGAPORE

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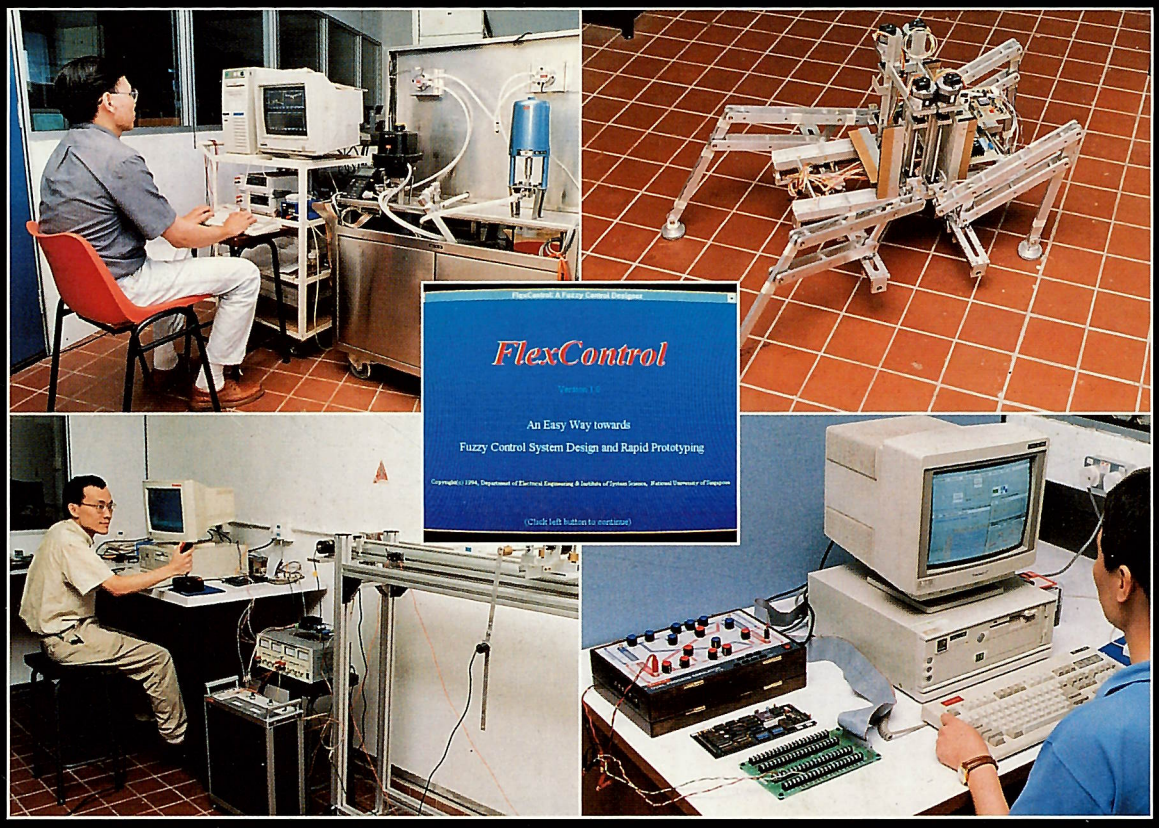
CONTROL



Department of Electrical Engineering

ABSTRACT

This report presents a summary of the activities of the Control Division at the Department of Electrical Engineering, National University of Singapore, during the academic session 1993-1994.

The focus of the report is on teaching and research activities. The former serves to impart basic and advanced control knowledge to undergraduate and postgraduate students. The latter has concentrated on the general field of intelligent control and specialized research topics such as automatic tuning methods, adaptive control systems, neural and fuzzy control, intelligent motion control, computer-aided engineering of advanced controllers, and knowledge-based control using expert system methodologies.

The Division has contributed towards international research by publishing fifty-eight papers. The seminars organised by the Division were well attended by research students and engineers from the local industry. The current total strength of the Division is thirty-five, consisting of eleven lecturers, four research scientists, one post-doc fellow, seventeen scholars (10 M.Eng & 7 Ph.D.), two research assistants, two technicians and one professional officer.

CONTENTS

ACTIVITIES REPORT 94 / 95

1. INTRODUCTION

This is the tenth report of the Control Division at the Department of Electrical Engineering, National University of Singapore. It presents an overview of the activities of the Division and its research interests during the academic session 1993/94.

A great deal of effort has gone into the continuing development of the Control Laboratories. In addition to long-term fundamental research, the activities of the Division encompass also the design and practical applications of advanced control theory. This is appropriate as Singapore is still a Newly Industrializing Country and there is a strong demand for engineers with practical control and automation expertise. The local industry is also just beginning to have in-house capability to translate theory into practice and our graduates can help to accelerate such development.

In this report, the objectives of the Division are outlined in Section 2. Research activities and student projects along with industrial collaborations are respectively described in Sections 3 and 4 while Section 5 lists the research facilities. In Section 6, undergraduate and postgraduate courses offered and research seminars are described. Section 7 lists the staff members, and publications of the division are in Section 8.

2. OBJECTIVES OF THE CONTROL DIVISION

The primary research goal of the Control Division is to establish a world-class research programme that is also of importance to local industry in the long term. The main focus is on control system design, engineering and technology development. The objectives are the development and refinement of leading edge control design methods and application softwares for improved process control and automation using microprocessors and microcomputers.

The basic approach is to either make use of the low-cost and widely available PC as a platform of technology development, or to augment the currently available industrial control packages. R & D are done using medium and high-end workstations. New developments such as the automatic tuning of discrete PID controllers, process modeling and identification for advanced control are added. Current and emerging theories as well as design methods are studied, refined and tested in simulation and on pilot processes. The software packages thus generated are intended for demonstration to local industry and training of control personnel. Features such as fail ure protection and modern operator interfaces are added to facilitate industrial applications. These packages may also be used for the computer-aided analysis and design of control systems. Where appropriate, for instance in the area of knowledge based control and neural networks, more fundamental research will be carried out to investigate new ideas.

The advent of microcontrollers has opened up new possibilities for the development of low-cost intelligent controllers. A stand-alone microcontroller-based process controller card has already been developed and is presently in use in several projects in-house and with industry. Investigations are currently on-going for a second generation card using digital signal processing chips. Further development will be the networking of these process controllers to form an intelligent distributed control system. The Division is active in this area in view of its importance and relevance to the local industry.

Finally, the Division has also initiated projects in digital servomechanisms, such as motion controllers and robotic compliance cont rollers for applications in defence disk drives and factory automation. New approaches in control such as the use of neural nets, fuzzy logic and parallel processing have generated new possibilities.

3. CURRENT RESEARCH PROJECTS

A NOVEL SELF-TUNING CONTROLLER WHICH WORKS ON LOAD RESPONSE

An adaptive controller is required when the plant dynamics changes significantly and/or frequently. Though the model reference adaptive control and self-tuning regulators were proposed for this purpose and have received a great attention over the last three decades, their stability and robustness in face of plant uncertainty are very difficult to address and understand, and they have to be switched off when a load disturbance occurs. The state-of-the-art in this area is still far away from practical applications .

This project aims to fulfill this gap between theory and application by developing a novel self-tuning technique based on new closed-loop identification and controller tuning methodology from load disturbance responses. We have shown that with appropriate use of the Fast Fourier Transform (FFT), the plant frequency response can be given in terms of the Fourier transforms of plant input and output transients. But it contains the unknown initial time when the disturbance occurs. There are several possible ways to determine this time for plants with small dead time. Their properties are to be investigated. After this identification, the plant frequency response is converted into a general second-order rational function plus dead time model and a pole-placement controller is re-designed for it so that the control system can be adapted to plant dynamics change.

NONLINEAR PID CONTROL

Industrial controllers are mainly of PID type. It is thus important to have good tuning algorithms for them. Different schemes have been proposed in the literature and most of them are linear. A linear PID controller is limited in performance due to its structure and even becomes unacceptable for complex plants which require complicated compensation. Recently, nonlinear PID control has been introduced through different ways such as fuzzy logic, artificial intelligence and analytical techniques.

This project is to investigate nonlinear PID control further. For a typical plant with normalized dynamics and some performance objective, an optimal nonlinear controller can be obtained. This is however computationally expensive. It is not intended for on-line use but is used indirectly to design a nonlinear PID controller. One way to do this is to approximate the optimal controller by a nonlinear PID controller. Another way is to split a PID control into individual P, I and D actions, and compare each with the ideal action produced by the optimal controller to develop tuning formulas for nonlinear PID parameter settings. The developed rules are to be incorporated into a knowledge base for implementation.

NONLINEAR CONTROL OF pH PROCESSES

Simple regulators of PID type are widely used in industry. They are suitable for monotonic processes with small dead time and modest uncertainly, but their performance is limited due to its linear structure if a processe has inherent nonlinearility. A typical example for this is pH process. This process is very common in IC and process industries. In order to enhance control performance, a nonlinear compensation should introduced.

This project is to investigate nonlinear control of pH processes. By looking into process dynamic models, nonlinear control methods such as feedback linearization, sliding mode and fuzzy logic may be applied to the processes. Closed-loop stability and robustness are to be analyzed. Design issues are to be addressed. However, these methods usually result in a complicated nonlinear control which is not easy for practising engineers to understand and implement. The next stage is then to approximate it by a nonlinear PID controller, which is a PID controller with nonlinear/time-varying gains. The performance analysis and auto-tuning of nonlinear PID controllers are then important issues to deal with.

KNOWLEDGE-BASED CONTROL

In this project, we will build a Knowledge-Based Controller using the expert system shell G2. The goal is to implement an autonomous control system for process control application. Such a system, once configured, will require minimum operator intervention. Most process controllers are of the PID type. Therefore the PID controller auto-tuned through relay feedback will still function as the basic controller. Key modules in the Knowledge-Based Controller include (1) PID control for processes with small dead-time , (2) Smith Predictor for processes with long dead-time, (3) neural network/fuzzy control for nonlinear processes and (4) explanation facilities so that it can function like a human expert who can explain the reasoning processes behind his recommendations.

The various modules will be coordinated using the blackboard architecture.

A number of Expert Systems have been used for off-line design of a multi-variable system. Real-time on-line knowledge-based control has been implemented mainly for SISO systems. In this project, we also attempt to develop an expert system for real-time on-line auto-tuning of controllers for multi-variable systems.

PARALLEL ADAPTIVE NEURAL NETWORK CONTROL OF ROBOTS

A parallel adaptive neural network controller design for robots was examined. The controller is based on direct adaptive techniques and an approach of using an additional parallel neural network to provide adaptive enhancements to a basic controller, which can be either a neural network based nonlinear controller or a model-based nonlinear controller. It is shown that if Gaussian Rad ial Basis Function networks are used for the additional parallel neural network , uniformly stable adaptation is assured and asymptotic tracking of the position reference signal is achieved.

ADAPTIVE STATIC NEURAL NETWORK CONTROL OF ROBOTS

A novel neural network model of robots was introduced by using the neural networks to model the inertia matrix and gravitational potential energy only. Its structural properties, such as the linear-in-the-parameter dynamics, are investigated to facilitate controller design. The networks are static networks and the size of the resulting model is much smaller than the dynamical one. Subsequently, a general controller based on the resulting neural network model is discussed. It can be shown that all the closed-loop signals are bounded and tracking error goes to zero.

COMPUTER-AIDED ENGINEERING OF ADVANCED CONTROL SYSTEMS

A complete design process of a real-time digital control system can be seen as consisting of four phases: Design, simulation , implementation and field test. Thanks to the advancement in the area of CAD for control systems, the design and simulation phases can now be conveniently done on many existing software packages (such as MATLAB and SIMNON).

For their hardware connection and real-time requirement, the last two phases, namely, implementation and field test, often need to be done on platforms other than the one for the first two phases. The concept of controller CAE (to be distinguished from CAD) is int roduced in bridging this gap. It intends to offer a platform so that all the phases of the design process can be carried out with minimum effort. In other words, it is the provision of rapid prototyping that distinguishes a CAE control design platform from a CAD one.

CAE as an engineering tool, though widely used in certain engineering fields, is only beginning to emerge in the control field recently. Few control design systems available in the market can be called a CAE system. Closer ones are Matrix-X which integrates the code-generation and rapid prototyping with the controller design, and d-Space which has a real-time interface linked at a range of specially designed hardware controller boards.

The CAE system that the project intends to produce distinguishes itself from all these existing systems in the following as pects:

First, while the above mentioned two systems are aimed at a wide range of control applications, our project intends to limit the scope to relatively slow process control problems. This scope allows us to seek a PC based solution and to make use of microcontrollers, which are far less costly.

Second, unlike the existing systems, we intend to build the software control design system as an open system. This allows a tested controller (either designed by the system, or elsewhere) to be maintained in the system as a module. If it is needed it can simply be called upon and reused without going through the design again.

Third, the system will be built in such a way that it leaves room for incorporating more advanced expert-design procedures for controller design wherever possible. This idea of expert-design of controllers opens up an exciting new research area.

Currently, the extensive research and development work are under way to build the prototype CAE systems. As a result, a CAE based fuzzy control system has been built, and is fully functional.

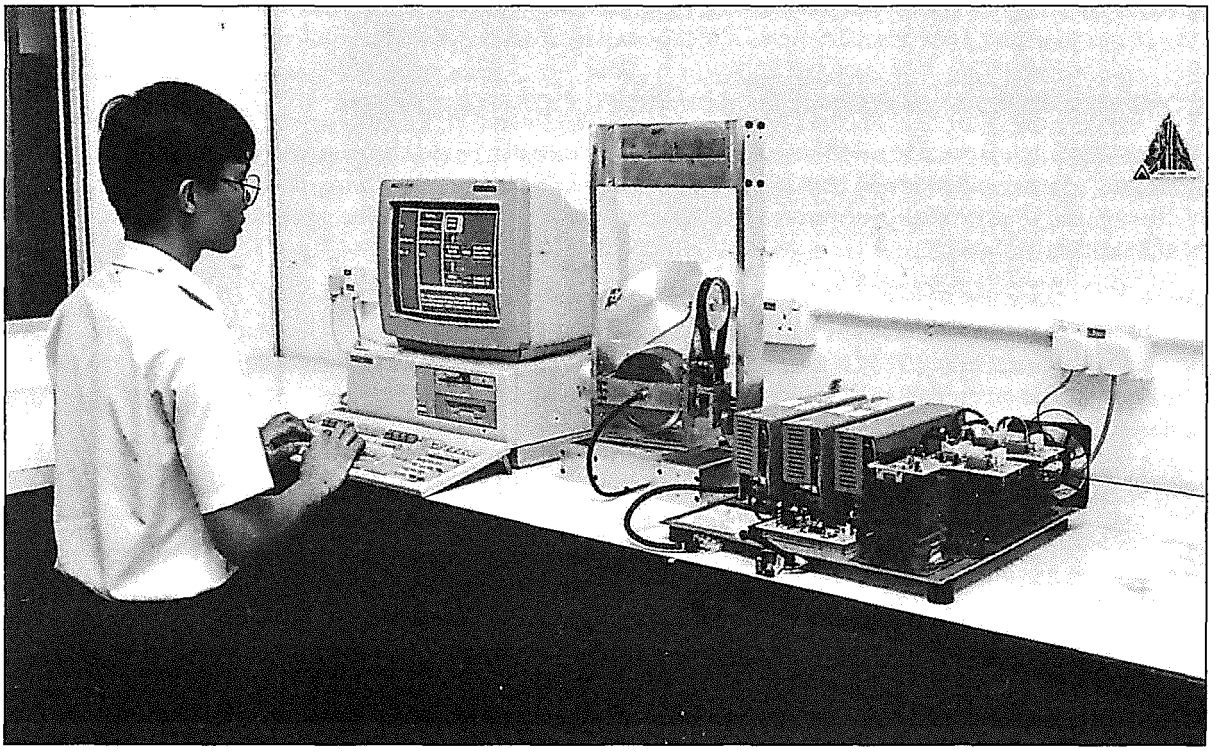
NONLINEAR SYSTEM IDENTIFICATION USING UNCONVENTIONAL METHODS

System identification has long been regarded as an important research topic, in areas such as control and signal processing. It is useful for characterizing nonlinear systems or signals into a form suitable for analysis, design, feature extraction, data compression, etc.

System identification techniques have been extensively developed for linear systems. For nonlinear systems, however, the identification still appears to pose a great challenge. Many available nonlinear system identification techniques often have specialized natures, and are far from being effective. With increasing demand from the application fields, there seems to be a real need to develop powerful nonlinear system identification techniques that are both general and effective.

Our on-going research shows that instead of restricting ourselves to finding appropriate representation structures and parameterest imation algorithms, as suggested in the conventional methods, we should look into the direction of on-line model structure generatio n for effective nonlinear identification. Such an idea appears to be realizable using collective structures, such as neural networks or wavelets that are attracting greater attention these days.

Thus, in this research project, we examine the feasibility of the on-line structure generation as a way for nonlinear system identification, intend to develop an effective scheme of this kind based on neural networks and/or wavelet and relevant theory.



4. STUDENT PROJECTS

4.1 POSTGRADUATE PROJECTS

Name	Project Title	Date of Comm.	Supervisors
Full-Time PhD			
Mr Fong Kin Fui	Discrete Time Optimal Control Using Neural Nets	21 May 1990	AP Loh V Srinivasan
Mr Liu Chen	Adaptive Learning and Expert Control Using a Fuzzy System Approach	0 Oct 1992	CC Hang JX Xu
Mr Wang Mao	Variable Structure Control Using Fuzzy System Approach	7 Nov 1992	JX Xu TH Lee
Mr Tan Kok Kiong	Investigations in Applied Nonlinear Control	23 Apr 1992	TH Lee QG Wang
Mr Tan Wee Kheng	Neural Networks in Motion Control	23 Apr 1992	TH Lee QG Wang MH Ang
Mr Quek Choon Kiong	Multivariable Control Systems Analysis and Synthesis	19 May 1992	AP Loh BM Chen
Mr Zhang Xing Hu	Identification and Controller Based on Fuzzy Neural Networks	6 Sep 1993	CC Hang PZ Wang SH Tan
Full-Time M.Eng			
Ms Wang X iao Wei	Synthesis of Intelligent Control System with Robust Control Approaches	30 Aug 1993	JX Xu
Mr Sun Bo Ming	Synthesis of Intelligent Control System with Robust Control Approaches	0 Aug 1994	JX Xu
Mr Yu Yi	Nonlinear System Identification Using Nonconventional Methods	31 May 1993	SH Tan
Mr Gan Oon Peen	Autonomous Control	19 April 1994	WK Ho TH Lee
Mr Chen Qi	Application of Neural Network and Fuzzy Logic on Power System	1 Jun 1994	SH Tan
Mr Zou Wei	Nonlinear PID Control	18 Jul 1994	CC Hang QG Wang
Mr Bi Qiang	Applied Adaptive Control	7 Aug 1994	QG Wang
Mr Zou Biao	Robust and Multivariable Control	29 Sep 1994	QG Wang
Mr Zhu Ge	Adaptive Control of A Single Link Flexible Beam	12 Jul 1994	SZ Ge
Mr Jiang Qin Qin	Computer Aided Engineering of Control Systems	21 Mar 1994	SH Tan

Part-Time M.Eng/PhD

Mr Pok Yang Ming	Analysis, Synthesis and Development of Fuzzy Control System	30 Nov 1993	JX Xu
Mr H Premawardena	Computer Aided Engineering of Control Algorithms System	15 Oct 1993	WK Ho

4.2 UNDERGRADUATE PROJECTS

1.	Abd Talib B Md Abd Kadir	Development of stand-alone general purpose digital controller	Dr SH Tan
2.	Chua Beng Huat	Control of a crane	Dr TT Tay
3.	Goh Heng Huat	Intelligent mobile robot with fuzzy system approaches	Dr JX Xu
4.	How Beng Hua	Graphically programming instrumentation systems with LabVIEW	Dr TT Tay IME
5.	Hong Shyh Poh	Neural fuzzy control system	Dr SH Tan
6.	Khor Chune Titt	Building a neural controlled double inverted pendulum system	Dr SH Tan Dr TH Lee
7.	Koh Ming Sue	Control system design for a walking robot	Dr SH Tan Dr Y Ding
8.	Koh Wan Taow	Adaptive flight control	Dr JX Xu Dr TH Lee
9.	Ku Wei Kian	Development of a fast digital control	Dr TT Tay
10.	Lim Chee Wee	Automatic screw-driving process using adapt-two robot	Dr TJ Lie
11.	Lim Chin Thong	Modeling of discrete event systems using Petri Net	Dr JX Xu
12.	Lim Lian Joo	Derivation of a discrete-time version of dominant pole design for PID controllers	Dr B M Chen Dr WK Ho
13.	Lim Meng Kwang	Implementation of routines for dominant pole design in a compiled language	Dr BM Chen Dr WK Ho
14.	Lim Min Chim	Self-tuning of Smith predictor: techniques, implementation and experiments	Prof CC Hang Dr QG Wang
15.	Lim Yuet Har	The use of nonlinearities to reduce the effect of noise on the control signal of simple cont rollers (such as PI or PID controllers)	Dr BM Chen Dr WK Ho
16.	Ng Koon Book	Fuzzy switching control of dynamical processes	Prof CC Hang Dr SH Tan

17.	Pua Lip Peng	Development and analysis of new learning control algorithm	Dr JX Xu Dr TH Lee
18.	Seah Kwang Leng	Development of a remote monitoring system	Dr TT Tay
19.	Tan Wee Hoe	Simulation study of adaptive predictive optimal control	Dr TJ Lie
20.	Tan Gim Hong	Networking of infant warmers	Dr AP Loh
21.	Tey Hwee Choo	Multivariable controller design using the Characteristic Loci	Dr AP Loh
22.	Toh Hoon Chew	Neural net control of a nonlinear process	DR AP Loh
23.	Tsai Yu Shee	Comparative study of adaptive VSC	Dr TH Lee Dr JX Xu
24.	Yip Chan Keong	Self-tuning of PID controllers using fuzzy logic	Dr WK Ho
25.	Yong Meng	Tutorial package for adaptive control	Dr WK Ho Dr TH Lee

4.3 INDUSTRIAL COLLABORATION

1. **Company** : Fisher-Rosemount System, Inc.
   Investigators : W.K. Ho, C.C. Hang and Q. H. Tao
   Type of work : To design a self-tuning PID control algorithm for distributed control system.
   Expected results : This project has resulted in a new algorithm and a patent on the algorithm is currently being filled by Fisher-Ros emount. Fisher Rosemount plans to implement this algorithm on their distributed control system.
   Current status : The design is completed.

2. **Company** : Defence Science Organisation
   Investigators : Dr T.H. Lee, Dr Shuzhi S. Ge Dr Marcelo H. Ang Jr. and Dr R Oruganti
   Type of work : Design, modelling and control of two degrees-of-freedom indirect drive platforms.
   Expected results : Different mechanical designs are to be proposed, compared and selected based on the design specifications. Controller design and computer simulation tests shall be carried out. Finally, a prototype mechanical system will be constructed and control algorithms will be tested.
   Current status : Investigation in process.

3. **Company** : CEI Systems Pte Ltd

   Investigators : CC Hang, QG Wang, WK Ho and DS Chen

   Type of work : Implementation of a frequency-domain auto-tuning technique for PID and advanced controllers.

   Expected results : Application of this auto-tuning technique in various industrial processes for improvement of control performance and efficiency of control implementation.

   Current status : Project has just started.

4. **Company** : DSO Guidance and Control Lab

   Investigators : BM Chen, TH Lee, EK Poh

   Type of work : Investigation of robust control strategies for flight control problems.

   Expected results : Design robust controllers using H-infinity optimization and propose a gain scheduling scheme for a F-15 aircraft control problem.

   Current status : Investigation in progress.

5. RESEARCH FACILITIES

1) Computer facilities to support the research activities of the laboratories include:

   a) A HP9000/360 CH workstation running HP-UX.6.2
   b) Three graphic terminals connected to the Dept's VAX 750 super-mini
   c) Two programmable controller systems
   d) A number of PC/AT compatible microcomputers
   e) A number of 80386/486 microcomputers

2) Pilot plants for system testing include:

   a) A level and flow pilot process with extensive electronic instrumentation
   b) Adept II robot manipulator system
   c) Bench top processes such as a ball and beam apparatus and a coupled drives apparatus
   d) A shell-and-tube heat exchanger pilot process
   e) Two sets of flow measurement test bed
   f) Two sets of pressure sensing test bed
   g) A pH control system.

3) Work on the implementation of distributed digital controllers is supported by:

   a) An Intel Series III/IV microprocessor development system
   b) Various board level system design kits such as the SDK 51
   c) An electromax V controller
   d) A Toshiba multivariable one-loop controller plus system loader
   e) Single station microcontroller
   f) A Foxboro EXACT adaptive controller
   g) A SattControl ECA 40 auto-tuning controller

4) Software packages available include

   a) SIMNON for system simulation
   b) IDPAC for system identification
   c) DDCEXP for digital control
   d) MATRIX-X
   e) MATLAB
   f) NEXPERT Expert System Shell
   g) Onspec 386
   h) Mathematica
   i) FIDE

6. COURSES AND SEMINARS

6.1 UNDERGRADUATE COURSES

EE301 Mathematics
Complex analysis. Numerical analysis. Discrete dynamical equations. Z-transform. Probability and statistics. Optimization. Queuing theory.

EE304 Control
Elements of feedback control systems. Mathematical models. Digital simulation. On-off and proportional control actions. Integral and derivative control actions. Transient and steady state error analysis. Routh-Hurwitz stability criterion. Root locus method. Nyquist stability criterion. Relative stability. Closed-loop frequency response. Phase-lead and phase-lag compensators. Computer-aided control system design.

EE441 Control Systems I
Examples of practical control systems in factory automation, aircraft and process control. Measurement fundamentals. Transducers and actuators. Analogue and digital signal transmission. Signal reconstruction and the sampling theorem. Z-transform and pulse transfer function. Process simulation. Stability analysis of discrete systems. Root-locus analysis. Digital compensators and controllers. Computer-aided control system design. Logic protection and sequence control.

EE442 Control Systems II
Supervisory and direct digital control. Controller refinements for ease of operator interface. System commissioning and maintenance. Control structures such as cascade, ratio, feedforward, selective and split-range. Process identification: Correlation techniques and least squares estimation. Effects of nonlinearities on control performance and stability. Introduction to state space analysis and design of continuous and discrete systems. Observer-controller design.

EE443 Robotics and Vision
Robot arm kinematics. Robotic arm dynamics. Trajectory planning. Dynamic control. Sensors. Image formation. acquisition and processing. Image analysis.

6.2 POSTGRADUATE COURSES

EE5101 Linear Systems
State space descriptions. Linear state variable feedback. Asymptotic observer and compensator design. State space and matrix fraction description of multivariable systems.

EE5102 Multivariable Control Systems
Review of single loop feedback design. Poles. zeros and stability of multivariable feedback systems. Performance and robustness of multivariable feedback systems. Multivariable design: Nyquist like techniques. LQG Methods. Computer aided-design.

EE5103 Computer Control Systems
Mathematical background. Discrete equivalents to continuous transfer function. Direct digital control and supervisory control. Control strategies. Process modelling and identification. Quantization effect. Analysis of finite wordlength. Implementation issues in digital control.

EE5104 Adaptive Control
Introduction to adaptive control. Real-time parameter estimation. Model reference adaptive systems. Self-tuning regulators. Auto-tuning. gain scheduling and alternatives to adaptive control.

EE5105 Optimal Control Sytems
Mathematics of control and estimation. Optimal trajectories and neighbouring optimal solutions. Optimal linear state estimatin. Optimal non-linear state estimation. Optimal control. Linear Multivariable Control. Robustness issues.

EE5204 Servo Engineering
Discrete systems, Z-transform, sample rate selection, design by transform techniques, design by state-space methods. Disk drive dynamic and control.

6.3 RESEARCH SEMINARS

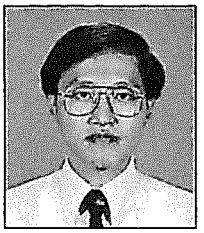
	Topic	Speaker	Date
1.	Two Topics in Multivariable Control	V/P CA Harvey	12.4.93
2.	Intelligent Control Engineering: An Overview of Some Recent Projects at Lund Institute of Technology	Dr. Karl-Erik Arzen	16.7.93
3.	Tuning of PID Controllers Based on Gain Margin and Phase Margin Specifications	Ms. Cao Lisheng	12.7.93
4.	MATLAB to C Compiler	Mr. MS Borujeni	27.8.93
5.	Collaboration with Fisher-Rosemount	Dr. WK Ho	5.10.93
6.	Combined Adaptive and Fuzzy Control using Multiple Models	Dr. JX Xu	20.10.93
7.	A Modified Relay-Based Technique for Improved Critical Point Estimation in Process Control	Dr. TH Lee	29.10.93
8.	Closed-loop Identification & Controller Tuning	Dr. QG Wang	23.2.94
9.	How we Merged Artificial Intelligence & Fuzzy Engineering: A Hybrid Approach for the Design of Intelligent Systems	Prof. Sosuke Iwai	16.3.94
10.	A PID Autotuner Based on Pattern Recognition: A Formal Approach	A/P R. Devanathan	30.3.94
11.	A Model-based Adaptive Sliding Controller	Dr. TH Lee	12.4.94

7. STAFF LIST

7.1 TEACHING STAFF

Dr CC Hang
Professor

Research Interests:
Auto-tuning and Adaptive Process Control: Intelligent Control: Knowledge-based. Neural Network Based and Fuzzy Control: Computer-Aided Engineering of Advanced Controllers.



Dr T H Lee (Division Head)
Senior Lecturer

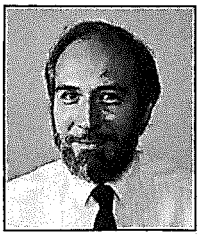
Research Interests:
Stable Adaptive Systems. Knowledge-based Control. Intelligent Motion Control.

Dr T J Lie
Senior Lecturer

Research Interests:
Robotics. Industrial Robots and Applications.

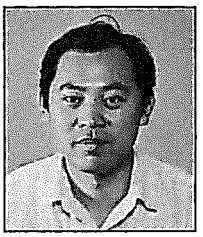
Dr A P Loh
Senior Lecturer

Research Interests:
Intelligent Process Control. Neural Nets in Control. Fuzzy Logic Control. Biomedical Applications.



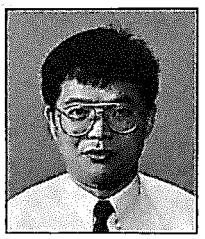
Dr L Smith
Senior Lecturer

Research Interests:
Process Control, Auto- and Adaptive Tuning of PID and Incremental Controllers, Fuzzy Control



Dr S H Tan
Senior Lecturer

Research Interests:
Neural Nets. Neural Control. Fuzzy Decision Systems. Fuzzy Control.

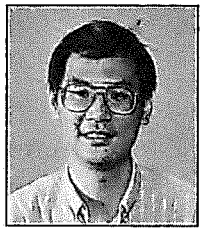


Dr Q G Wang
Senior Lecturer

Research Interests:
Robust Control. System Theory. Adaptive Control and AI with Applications in Process Industry and Robotics.

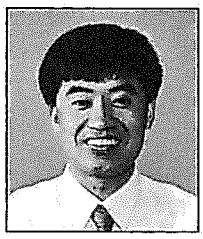
Dr J X Xu
Lecturer

Research Interests:
Intelligent Control Using Fuzzy Logic and Neural Net Approaches. Variable Structure System Based Robust Control and Signal Processing. Application of Intelligent and Robust Control Strategies to Process Control and Motion Control Problems.



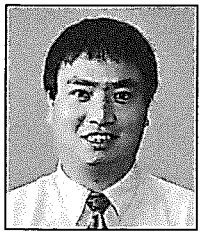
Dr WK Ho
Lecturer

Research Interests:
Intelligent Control, Knowledge-based Control, Intelligent PID Control.



Dr S Z Ge
Lecturer

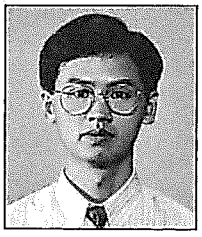
Research Interests:
Robotics, Adaptive Control of Nonlinear Systems, Neural Network Adaptive Control.



Dr B M Chen
Lecturer

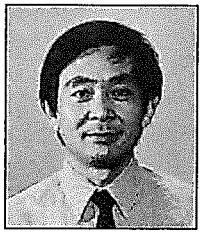
Research Interests:
Robust and Optimal control, Linear Systems Theory, Control Applications.

7.2 RESEARCH STAFF



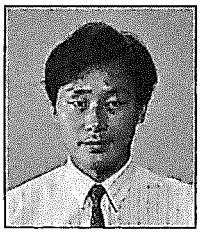
Dr Y Ding
Research Scientist

Research Interests:
Robotics. Force Control. Planning. Walking Robot.



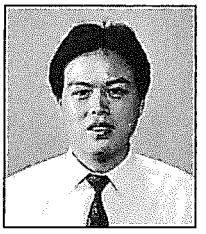
Dr J H Nie
Research Scientist

Research Interests:
Intelligent Systems and Control. Approximate Reasoning. Learning Systems. Fuzzy and Neural Systems and Control. Applications to Biomedical and Industrial Engineering.



Dr Q H Tao
Research Scientist

Research Interests:
Nonlinear System Identification and Control Neural Networks. Genetic Algorithms.



Dr D S Chen
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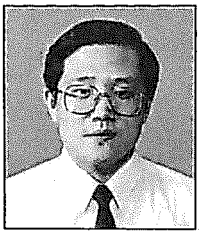
Research Interests:
Intelligent Control on Autopilots. High Precision Control of HP Laser Positioning System.



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Research Interests:
Process control, adaptive control and control neural networks.

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