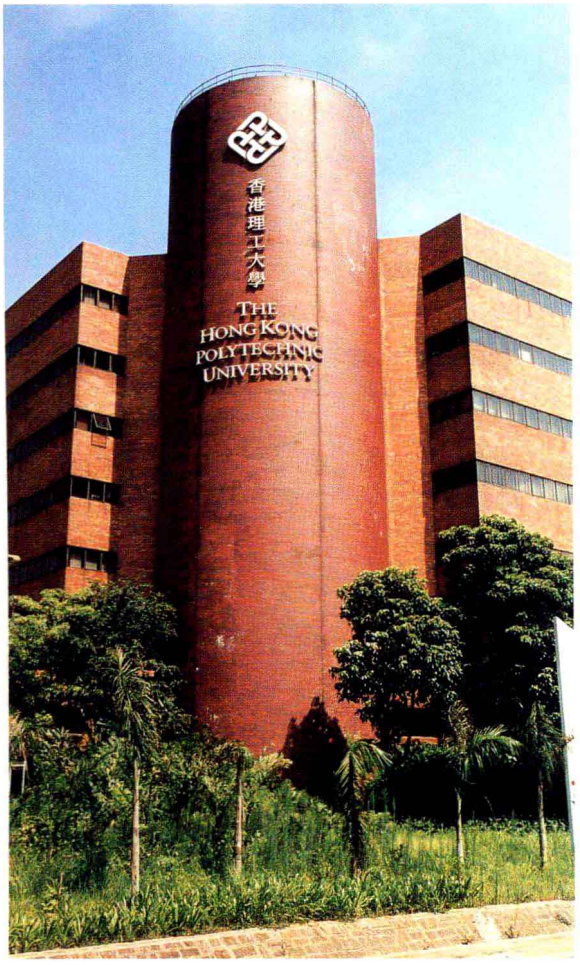
THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

Research in

Department of
Mechanical Engineering



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This report was edited by the Publicity Committee (Y.S. Ho, Chairman; C.S. Cheung; H.K. Fung; C.W. Leung; S. Wan and L.H. Yam) from material supplied by the faculty.

January 1997

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Foreword

It is the mark of an educated mind to rest satisfied with the degree of precision that the nature of the subject admits, and not to seek exactness when only an approximation is possible.

Aristotle (*Nicomachean Ethics*, 3rd Century BC)

This is the gist of applied research, especially in engineering. The Hong Kong Polytechnic University encourages high quality applied research that is germane to Hong Kong and its surrounding region. Since the University was established from the original Polytechnic, it has a long tradition of doing engineering research that has contributed to the phenomenal economic success of Hong Kong in the past quarter century. The Department of Mechanical Engineering strives to uphold this tradition while, at the same time, to strengthen its basis by engaging in the pursuit of the underlying arts and sciences of mechanical engineering.

The research activities in the Department are divided into four main groups; the Dynamics & Control Group, the Mechanics, Materials & Design Group, the Teaching Innovation Group and the Thermofluids Group. These groups are organised based on the research expertise of the staff and the needs of Hong Kong. At present, the staff has expertise in automation and control, advanced materials and mechanics, flow-induced vibrations, multi-media teaching and other related areas. Consequently, many projects in the Department are focused on these problems. Even though the research projects carried out are targeted towards the needs of Hong Kong, the true meaning of research is not lost in this pursuit. Basic research that contributes to a better understanding of the above areas is also pursued with equal interest and effort. For example, research into the basic characteristics of turbulent flow structure is carried out simultaneously with work on the flow-induced vibrations of bluff bodies in a cross-stream. The various projects and their possible applications to Hong Kong industry are described in detail in this brochure.

The University offers a Distinguished Visitor Programme to encourage academics and researchers of stature to visit the various Departments within the University. Since most of the staff in the Department are novice in research, the Department took advantage of this opportunity and invited four distinguished researchers to visit in the 1996/97 academic year. They are Professor S. R. Reid of UMIST, Professor J. H. Whitelaw of Imperial College, Dr. H. McDonald of NASA Ames Research Centre and Professor C.L. Tien, Chancellor of the University of California at Berkeley. Professor Reid served his Visiting Professorship from 1 July - 31 December, 1996, while Professor Whitelaw, Dr. McDonald and Professor Tien joined the Department as Distinguished Visitors for one week during December 1996, March 1997, and May 1997, respectively. Their presence has no doubt contributed to the Department's research effort and, at the same time, guided the relatively young and inexperienced staff in their research pursuit. The Department benefits greatly from their visits and wishes to thank them for their participation.

This brochure offers the reader a glimpse of the research activities in the Department during the 1995 and 1996 calender years. It aims to stimulate the reader's interest and curiosity. For those who wants to know more about these activities, please do not hesitate to contact the Head, Professor Ronald M. C. So, for further details. He can be reached at 852-2766-6642 or fax at 852-2364-7183 or at the e-mail address: mmmcso@polyu.edu.hk.

Ronald M. C. So
Chair Professor & Head

Research in Dynamics and Control

A STUDY ON VIBRATION OF NON-UNIFORM BEAMS

K.T. Chan and T.P. Leung

The Hong Kong Polytechnic University

A new, exact and efficient method to analyze vibration of certain kinds of non-uniform beam structures has been proposed. Mathematical formulation of the eigenvalue problems of the structures from differential equations has been completed. Experiments have also been carried out to validate the method. This has been applied to uniform beam models loaded with regions of distributed mass. The vibration problem of a stepped beam is being studied in details using the new method with the objective of investigating the effect of stress concentrations on the natural frequency of the beam. The stepped beam was manufactured with the help of the Castle Peak Power Station. Results have shown that local stress concentrations at the corner reduce the natural frequency, agreeing with literature results of local reductions of stiffness. The eigenvalue problems of beams partially loaded with masses have also been formulated in integral equation form. The benefits of this kind of formulation as compared with the differential counterpart are being studied in detail.

Research Student: X.Q. Wang

TRAJECTORY CONTROL OF A HYDRAULIC SERVO SYSTEM SUBJECTED TO UNKNOWN DISTURBANCES

C.W. Chuen and T.P. Leung

Unsponsored

This project aims at studying and developing different algorithms to control the trajectories of hydraulic servo-systems subjected to unknown disturbances. In this project, three hydraulic power systems have been developed to study the three control methods: viz. valve opening area control, supply pressure control through fixed orifices and digital valve control with load-dependent supply pressure. In the presence of periodic disturbances, iterative learning control provides acceptable performance while a fuzzy knowledge-based control system can provide more stable and smoother performances and faster control actions for systems subjected to non-repetitive and random disturbances.

Research Student: C.M. Liu

DESIGN AND DIAGNOSIS OF FLUID POWER SYSTEMS: AN EXPERT SYSTEM APPROACH

C.W. Chuen, T.P. Leung and T.T. Wong

The Hong Kong Polytechnic University

This project aims at developing an integrated approach to the design, maintenance and diagnosis of fluid power systems. The design of fluid power systems can be regarded as an engineering process to realize some desirable operations using fluid power components. When the operations deviate from their expected states, some diagnosis and repairs must be carried out to restore their normal operation states. The maintenance process keeps the operations in their desired states. In order to provide an integrated approach to these processes, a set of Change Theories have been developed and the algorithms will be implemented using microcomputers.

Research Student: K.K. Kong

NAVIGATION OF AUTONOMOUS OUTDOOR VEHICLE

H.K. Fung

The Hong Kong Polytechnic University

The objectives of this research project are two-folded: (1) To study and integrate various navigation systems such as the Global Positioning System (GPS) which is for long term navigation and the Inertial Navigation System (INS) which is for short term navigation. Adaptive and autonomous control theory will be developed based on fuzzy logic theory and genetic algorithms in order to provide long term, high precision navigation. (2) To employ the GPS/INS system for navigation of an autonomous outdoor vehicle within an obstructed operating environment with sub-meter accuracy. The emphasis of the project is on navigating software development and data processing. A software interface which processes and integrates data from the GPS and inertial platform in the INS will be developed. This project focuses on the practical implementation of the navigating system for an outdoor vehicle.

Research Student: A.F.M. Chan

DESIGN AND FABRICATION OF A FAST PIEZO-ELECTRIC ACTUATOR

H.K. Fung

The Hong Kong Polytechnic University

Piezoelectric actuators are increasingly being used in precision positioning applications. They have received considerable attention as a possible and better replacement for an electromagnetic motor because of their compact mechanism, light weight, fast response, direct drive etc... The major disadvantage is the hysteresis property of the piezoelectric material which results in the non-linear relationship between the displacement and the

applied voltage. The project aims at the design and fabrication of a single body piezoelectric actuator that provides simultaneous two-dimensional (x-y) movement of the cutting tool. Control methods based on precompensator and learning control will be designed to ameliorate the nonlinearilty problem due to hysteresis to improve the actuator performance. The project will contribute to the in-depth understanding of the single body x-y piezoelectric actuator which will form a basis for future investigation of two-dimensional machining error compensation.

DYNAMIC HYBRID POSITION AND FORCE CONTROL OF A FLEXIBLE MANIPULATOR

H.K. Fung

The Hong Kong Polytechnic University

It is well known that light weight robot manipulators possess distinct advantages over conventional ones. However, the increased link flexibility resulting from reducing the link mass can pose undesirable problems of vibrations and instability, which are major concerns in practical applications and controller design. This project is aimed at developing hybrid position and force controllers for the two link rigid-flexible manipulator to perform various constrained tracking motions. The manipulator has been modelled using the Lagrange-Euler approach taking into account the non-homogeneous boundary condition at the constrained end. The infinite dimensional model will be reduced to a finite dimensional one for controller design purposes. To suppress the instability due to the spillover effects, robust controllers will be designed based on neural fuzzy logic principles and/or genetic algorithms.

Research Assistant: Z.X. Shi

UNCERTAINTY ANALYSIS AND FUZZY TRACKING CONTROL WITH APPLICATIONS TO AUTOMATICALLY STEERED VEHICLES

H.K. Fung and T.P. Leung

The Hong Kong Polytechnic University

Electric vehicles are going to replace the gasoline ones because of environmental considerations. They will be more safe and intellectualized in navigation when under proper control. This project aims to design control systems for the steering control of outdoor vehicles based on fuzzy logic principles, and to implement the control algorithms on an experimental rear wheel driven electric vehicle. The controller which is designed based on stability theory, model tracking and fuzzy logic principles, should possess the robustness towards parameter variation and uncertainties, and unknown disturbances. Up to now, only a few control schemes have tackled fuzzy logic issues in electric vehicle control and their algorithms are very complicated. Hence, there is a need to develop a number of simple and reliable schemes for electric vehicle control.

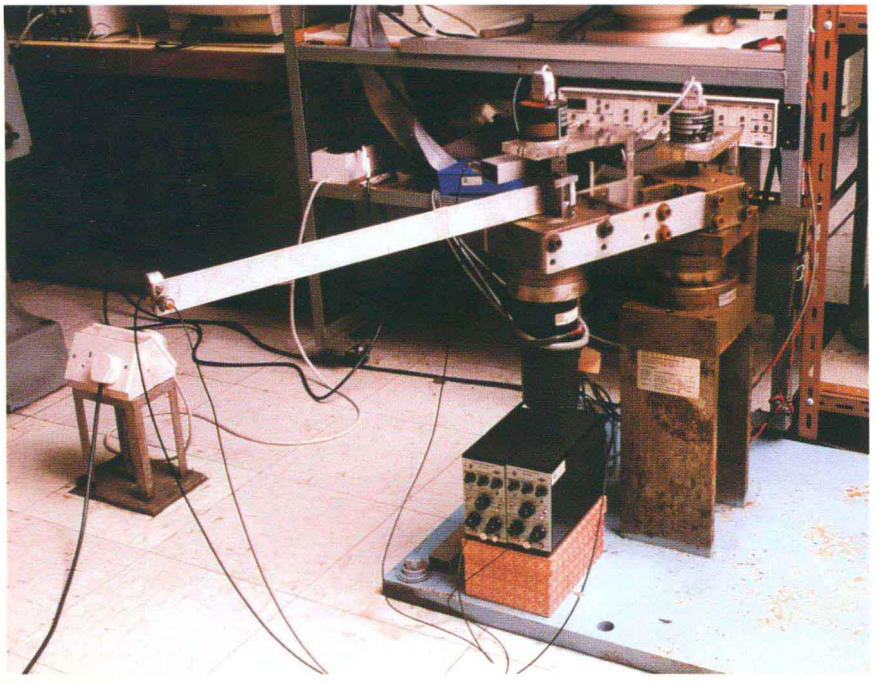
Research Student: D.J. Yu

DEVELOPMENT OF COMPACT WAVE SOLVERS

K.Y. Fung

The Hong Kong Polytechnic University
Partial support from NASA

Wave propagation is one of nature's fundamental processes. Many biological sensing systems depend on the reception of waves. The human experience is built largely on the reception of electromagnetic and acoustic waves. Our ability to probe into nature, from atomic structures to the universe and into the human body, and to understand fundamental physical processes such as fluid instabilities and turbulence, depends critically on our perception and understanding of wave phenomena. Although in many aspects the propagation of various types of waves is well understood, and highly sophisticated sensing systems have been developed for their detection, the prediction of wave phenomena remains an engineering challenge, especially when realistic geometries are involved. This project involves research and development of numerical schemes for accurate time-domain solution of the wave equation involving arbitrary surfaces of practical interest. The



features of these schemes are: 1) they are implicit and not restricted by a CFL stability condition, 2) their spatial accuracy is essentially fourth-order for various types of grid distributions, thus long-time accurate solutions involving curved surfaces are possible, 3) their numerical solution involves a simple data structure (three spatial points and two time levels) and inversions of tridiagonal matrices, 4) enforcement of exit or wall boundary condition is characteristically exact and numerically accurate to any desired order without changing the basic data structure or affecting the long-time stability of the scheme, 5) no body-conforming grid is required to enforce boundary conditions on curved surfaces, and 6) they are inherently suitable for parallel multiple-processor computing. These schemes can be developed into a uniformly valid integrated methodology for prediction of different types of waves in domains bounded by interior surfaces such as in nonintrusive testing and imaging, confined by exterior surfaces such as in room acoustics, and wave interactions between a wave cavity and its radiation field such as in musical instruments, wave guides and antennae.

SIMULATION OF UNSTEADY LAMINAR FLOW AND HEAT TRANSFER IN GROOVED CHANNELS

R. S. Iyer* , S. Kakac* and K.Y. Fung (*University of Miami, Florida, USA)

The Hong Kong Polytechnic University
Partial support from University of Miami

Two-dimensional laminar flow and heat transfer in a channel with periodic grooves simulating electronic components is computed by solving the Navier-Stokes and energy equations using a high-order finite-difference scheme. High-order accuracy is achieved using compact-differencing for spatial derivatives. Beyond a critical Reynolds number which varies significantly with wall geometry, the flow develops and sustains large-amplitude, time-periodic, nonlinear oscillations akin to the instability of the embedded shear layer. These oscillations enhance the heat transfer rate between the heated walls and the cooling fluid. An optimal component spacing is found to exist at which the flow exhibits a substantial heat transfer enhancement with a proportionally small increase in the driving pressure drop.

TIME-DOMAIN IMPEDANCE BOUNDARY CONDITION FOR WAVES

K.Y. Fung and B. Tallapragada* (*Andhra University, Visakhapatnam, India)

The Hong Kong Polytechnic University
Partial support from Andhra University and University of Miami

The reflection of waves from a boundary is conventionally modelled by giving the impedance Z(w) to relate the dependent variables in the frequency domain w. The investigators recently introduced a general, direct, and unconditionally stable method to transform Z(w) into a corresponding temporal operator W(d/dt) for time-domain solution of waves. This method is being employed in direct, time-domain simulations of resonance in cavities.

DYNAMICS OF FLOW IN A VALVE

K.Y. Fung and S. Saripalli* (*University of Miami, USA)

The Hong Kong Polytechnic University
Partial support from University of Miami

The dynamics of the flow in a closing and rebouncing valve is modelled and studied as an unsteady separating flow in the immediate downstream of a flow stagnation at a curved surface. A high-order compact finite-difference scheme for spatial discretization is developed and a Runge-Kutta scheme for temporal integration employed for solving the Navier-Stokes equations in vorticity and stream function form and in generalized curvilinear coordinates. Effects of high Reynolds number laminar flow is achieved by combinations of a Reynolds number and an acceleration parameter. It is believed that this model provides a better means for comparisons with experiment than the difficult experimentation of the unsteady separation of an accelerating flow over a cylinder. An application of this problem is to study the cavitation potential of a mechanical heart valve. We conjecture that cavitation is a result of vortex shedding at separation.

MONITORING OF LEAKAGE BY ACOUSTIC EMISSION TECHNIQUE

Y.S. Ho and T.P. Leung

The Hong Kong Polytechnic University

Leakage occurs in a number of industrial situations, and can have serious consequences. Acoustic Emission (AE) is one of the nondestructive testing techniques developed for the on-line monitoring of leakage. The AE parameters such as ringdown count, RMS etc used to characterise the signal caused by leakage are dependent on the characteristics of the system, and hence it is very difficult to compare and evaluate data about leakage obtained by different research groups. This project aims to investigate suitable methods and parameters that can be used to evaluate the Acoustic Emission signal due to leakage and would be independent of the characteristics of the measuring instruments.

Research Student: Q.M. Chen

DESIGN AND IMPLEMENTATION OF CONTROL AND COMPENSATION SYSTEMS FOR AN EXPERIMENTAL TURNING MACHINE

T.P. Leung and H.K. Fung

The Hong Kong Polytechnic University

An alternative low-cost approach to increase machining accuracy called Forecasting Compensatory Control (FCC) is based on on-line stochastic modelling and error compensation. The objective of this project is to improve the roundness accuracy in tapering small workpieces using the FCC technique. An experimental lathe has been designed and built. A new in-process roundness error measurement system has been developed for on-line error compensation in tapering. A master taper with precalibrated roundness data and a sensor were used in the error measurement to find the depth of cut in machining through the measurement of the relative motion between the sensor and the master taper. Autoregressive (AR) modelling was employed to model the experimental cutting data, and computer simulation was carried out to investigate the forecasting capability of the FCC technique with the selected model and the recursive parameter estimation technique. Cutting experiments with compensation using the piezoelectric toolpost were then performed under different materials and cutting conditions. The results showed that the average roundness accuracy of the workpiece was improved by at least 24% when forecasting and compensation techniques were employed. Future work will be mainly focused on the comparison of the AR and Auto-Regressive Moving Average (ARMA) modelling techniques in error forecasting.

Research Student: S.M. Cheung

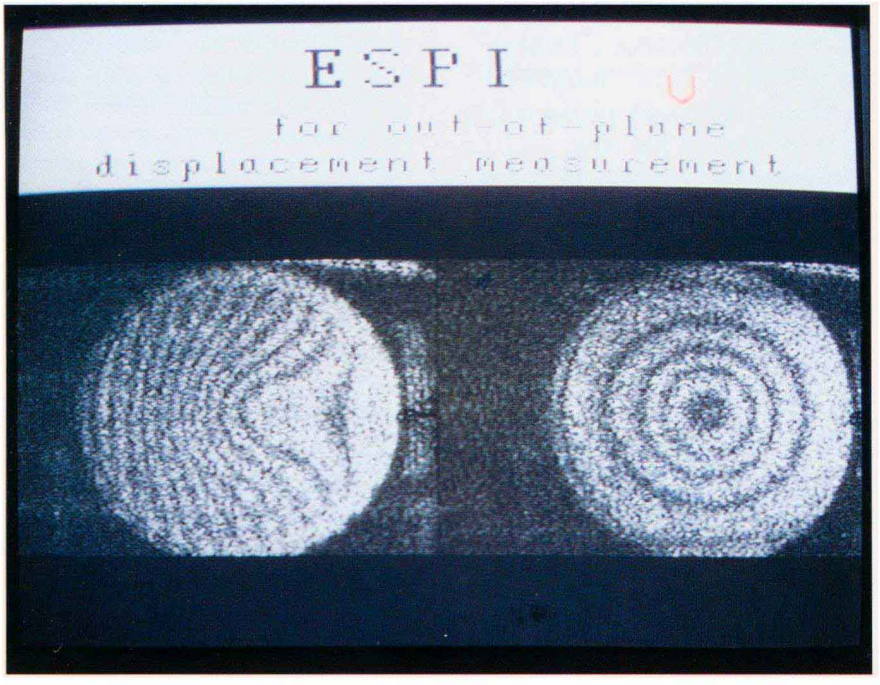
INVESTIGATION ON CMAC AND BP NEURAL NETWORK FOR ANALOGUE CIRCUIT MULTIPLE FAULT DIAGNOSIS

T.T. Wong and D.P. Kwok*
(*Department of Electronic Engineering, The Hong Kong Polytechnic University)

The Hong Kong Polytechnic University

Development of testing and fault diagnosis in the electronic industry has lagged behind the digital world. The main reason is that a robust analogue diagnosis method has to overcome the combined effect of component tolerance and measurement error. Most neural networks used to solve the problem are focused at system level or on single fault component detection. In this project a method based on a Cerebellar Model Arithmetic Computer (CMAC) and a Back Propagation (BP) neural network for multiple fault diagnosis is studied. The objective is to design a neural network to fit the nonlinear mapping between the circuit measurement space and the circuit component space.

Research Student: S.C. Zhou



VIBRATION MEASUREMENT and ANALYSIS BY ELECTRONIC SPECKLE PATTERN INTERFEROMETRY

W.O. Wong, K.T. Chan and T.P. Leung

The Hong Kong Polytechnic University

Laboratory experiments and theoretical studies are being carried out to investigate the techniques of electronic speckle pattern interferometry (ESPI) for vibration measurement. A new time average frame subtraction technique has been introduced for vibration analysis by ESPI or speckle shearing interferometry. The technique enables significant enhancement of fringe contrast and increased measurement sensitivity. The advantages of the method are a simple experimental setup and the allowance of dynamic viewing of vibration resonances. So far as qualitative measurement of vibration is concerned, this enhancement technique is more efficient than the phase shift method. Furthermore, fringe enhancement has been applied to speckle pattern shearing interferometry so as to facilitate the tracing of strain information in plate vibration.

THE DESIGN OF ACTIVE VIBRATION CONTROLLER FOR MECHANICAL SYSTEMS

L.H. Yam

The Hong Kong Polytechnic University

For a mechanical system with complicated and high-precision design requirements, such as robotics, rotor shaft, flexible arms, etc. vibration suppression is one of the most important considerations for the system design. This project is aimed at the synthesis of an active controller for damped vibration systems subjected to external disturbances. The study is also extended to uncertain systems using complex modal theory and robust control techniques. The δ -stabilizing region and the optimal performance index are defined as the measures of stability robustness and performance robustness. Experiments have been carried out to verify the design theory and to validate the numerical simulation results.

Research Assistant: Y.Y. Li

VIBRATION ANALYSIS AND ROBUST ACTIVE CONTROL OF THIN PLATE SYSTEMS

L.H. Yam, K.T. Chan and T.P. Leung

The Hong Kong Polytechnic University

In engineering practice, complex systems are generally regarded as large scale, distributed parameter systems (DPS). In many cases, a system can be modelled as a thin plate structure but its parameters cannot be determined accurately. The objective of this research is to develop the control methods and algorithms for robust active vibration control (RAVC) of thin plate systems. Compared with the lumped parameter systems, the RAVC design of DPS is more difficult, because issues such as model reduction, spill-over, model inaccuracies, optimal locations of sensors and actuators, controllability and observability, mutual coupling between the controlling elements and control de-coupling, etc., need to be considered additionally. Constructive conclusions will be drawn for engineering applications. Experimental verification will be carried out. The results of this study should be applicable to vibration suppression of large structures used in mechanical, aeronautical and structural engineering.

Research Student: Y.Y. Li

INTELLIGENT ROBOTIC SYSTEMS

J. Yuan

Unsponsored

This study consists of two projects covering two main aspects of robotics research: (1) intelligent decision making and (2) accurate control/execution. The ultimate goal of the first project is to develop software capable of optimal path planning for free-motion and hybrid force-motion tasks. It should also be able to detect obstacles and avoid collisions. At the present stage, an efficient neural network structure has been developed for collision detection and collision avoidance. More efforts are being devoted to full integration of the neural networks with other functions to form a complete intelligent decision maker. The objective of the second project is to control an industrial robot to execute the command of the decision maker with high accuracy. It involves free-motion tracking control and hybrid force-motion control. In both cases, the controller should be able to compensate for the nonlinear robot dynamics while the robot handles different payloads. The project has produced several journal publications. More new methods are being explored and the results are being implemented.

INTELLIGENT HYBRID COMPUTER VISION SYSTEM

D.W. Yuen and T.P. Leung

The Hong Kong Polytechnic University

Among the various approaches that exist in computational vision, image processing using conventional AI techniques, neural networks and fuzzy sets theory, no single approach has been found to be suitable for low-level, mid-level and high-level vision problems. It is believed that for a computer vision system to be really useful for a whole range of tasks and to adapt to new environmental changes, a hybrid approach which not only fuses information obtained from various techniques at different levels but also can make decisions about further actions is very important. This project investigates how to design an intelligent system based on the powerful blackboard architecture in which the various knowledge sources can be obtained by fuzzy, neural network or conventional image processing techniques. At high-level, the blackboard will control different inference engines such as production systems, frames and schemes can be used for different tasks. Distributed artificial intelligence and distributed control using many processors is possible with the blackboard architecture. It is expected that at the end of the project, a computer vision system suitable for a range of machine inspection tasks and also robot navigation will be produced.

KINEMATIC ANALYSIS AND DESIGN OF SPATIAL MECHANISMS AND INDUSTRIAL ROBOTS

Y.B. Zhou, C.M. Wong and W.H. Chan

Unsponsored

In order to control a serial industrial robot or design a spatial mechanism, the algebraic equations governing the motions must first be derived. This is

the core issue of the kinematic analysis of spatial mechanisms and robots. In general, the *Matrix Method* has been regarded as the most efficient one among many different methods developed in the past forty years. However, a newly developed method, the *Vector Algebraic Method*, has shown better performance compared to the matrix method. The present project is therefore focused on the application of the Vector Algebraic Method in the kinematic analysis of various kinds of spatial mechanisms and industrial robots.

Research in Mechanics, Materials and Design

SURFACE MAPPING OF THREE - DIMENSIONAL OBJECTS USING PLANAR LIGHT

W.H. Chan, C.M. Wong and T.W. Lam

The Hong Kong Polytechnic University

This project involves recording the images formed by a set of planar light illuminations cast on the surfaces of an object. The images are subsequently digitized and processed to obtain the geometrical shapes and dimensions of the surfaces with an accuracy comparable to common contact-type of digitizing. Initial work has been carried out to identify the factors affecting the accuracy of the process. This project takes an important role in the development of reverse engineering activity in the department, and is expected to be useful for product designers in Hong Kong.

FEATURE-BASED CAD/CAM FOR HYDRAULIC MANIFOLD BLOCKS

C.W. Chuen, C.M. Wong and L.H. Yam

The Hong Kong Polytechnic University

This project aims at the development of an integrated feature-based CAD/CAM system for a hydraulic manifold block with the following objectives: i) to analyze and define the features of a manifold block, ii) to form a feature library for manifold blocks, iii) to design and analyze the structure of hydraulic manifold blocks, iv) to develop a product model and a product model database, v) to interface with product model data exchange systems and solid modelling systems, and vi) to develop interfaces for the CAM processes. This project will contribute to the advancement of feature technology which forms a strong basis for developing other related technology. Fluid power system end-users could benefit from the results of this project, which will produce an integrated package for the manufacturing of hydraulic manifold blocks.

NON-DESTRUCTIVE EVALUATION OF AIRCRAFT COMPOSITE PANELS

C.L. Lam, T.P. Leung, M.J. Lalor* and D.R. Burton*
(*Liverpool John Moores University)

The Hong Kong Polytechnic University

The aim of the project is to investigate an optometric method for non-destructive evaluation of in-service defects in advanced composite panels. Defects like cracks, corrosion, delamination may occur in engineering systems after periods of services. Conventional NDT techniques such as ultrasonics, radiography, etc. cannot be applied successfully to composites due to the complexity of their construction. Besides locating defects, the effect of defects on structural integrity will also be assessed. Initially, stress/strain behaviour of the panels will be investigated numerically using finite element technique. Afterwards, various optometric testing techniques will be evaluated for applicability to the panels. The experimentally obtained interferometric patterns will then be correlated with the numerical findings. The effect of defects on structural integrity will also be assessed.

OPTOMETRIC AIDED PRODUCT DESIGN AND EVALUATION

C.L. Lam and T.W. Lam

Edward Sai Kim Hotung Fund

The research involves computer aided design of products/systems with optometric verification. The methodology of computer aided design and optimization is applied to a typical engineering component, casing of an electronic product. Initially finite element analysis is used to model, analyze and optimize the product. The analysis results will then be used to prepare a prototype for optometric evaluation. Holographic interferometry is employed because of its characteristics of being full field, non-destructive in nature and accuracy in the order of the wavelength of light. Interferogram in the form of fringe patterns is obtained from the experiment. These fringe patterns are then processed using a computer-based image processing system for interpretation of displacements, stresses and strains. The processed result is then evaluated for modification of the product.

NON-MANIFOLD FEATURE-BASED DESIGN AND ASSEMBLY

T.W. Lam and T.P. Leung

The Hong Kong Polytechnic University

The aim of this project is to derive a mixed-dimensional model, based on non-manifold feature-based modelling technology, for capturing and manipulating the designers' intentions and components' assembly relationship.

Recent work by the investigators has demonstrated a framework for explicitly storing the design and assembly information together with the geometric and topological information of an engineering product. The representation scheme is derived by classifying the various features to be supported in terms of their algebraic dimensionality. A topological data structure is shown to represent hierarchical relationships between feature and its highest dimensional topological elements directly. The problems of feature interactions and consistency of design data will be tackled. The algorithms for manipulating the various features will be developed. The proposed non-manifold feature-based modelling system could be used as a skeleton in a concurrent engineering environment.

THIN-SHELL BASED RAPID PROTOTYPING

T.W. Lam and K.M. Yu*
(*Department of Manufacturing Engineering, The Hong Kong Polytechnic University)

Unsponsored

This project investigates a 'sub-boundary' octree approach to produce a thin-shell based rapid prototyping model. A 'sub-boundary' octree means an octree that is wholly in the interior of the original solid. The octree solid is unioned with the reduced volume solid from negative offset to generate a reinforced interior structure. The studied method can speed up the rapid prototyping process by reducing the material volume to be traced. Theoretical studies are being carried out to develop a sufficient and efficient data structure for storing and editing of the 'sub-boundary' octree skeleton, to implement an efficient algorithm for deriving the 'sub-boundary' octree approximations from solids, and to verify the constructability of the theoretical results.

TOPOLOGICAL DATA STRUCTURE AND ALGORITHMS FOR CELL-COMPLEX BASED FORM FEATURE MODELING

T.W. Lam, M.M.F. Yuen* and W.S. Sze#
(*The Hong Kong University of Science and Technology,
#The University of Hong Kong)

The Hong Kong Polytechnic University

Topological data structure and algorithms for supporting cell-complex based non-manifold form feature modeling are investigated. A non-manifold boundary based form feature modeling topology representation structure is developed. Mix-dimensional form features are represented robustly and concisely. The topological adjacency relationships are stored explicitly. Boolean operators for the form feature model are defined in terms of three operations: merging, classifying and boundary evaluation. Classification algorithm is explored for grouping subdivided topological elements in interactive form features. A feature-oriented boundary evaluation algorithm is developed for the implementation of the boundary evaluator.

FINITE ELEMENT ANALYSIS APPLICATIONS IN FRACTURE MECHANICS

K.J. Lau

The Hong Kong Polytechnic University

The main objective of the project is to develop a finite-element-analysis-based procedure for evaluating stress intensity factor weight functions in finite cracked bodies. Two quantities have to be determined: the stress intensity factor of a reference load case and the partial derivative of the crack surface displacement with respect to crack length in association with this reference load case. Once these are determined the stress intensity factor for any set of loading on the same crack configuration can be found by very simple calculations. With respect to the first quantity a semi-infinite-crack model, making use of near-crack-tip displacements as calculated by FEA, has been developed. It has been applied to finite cracked geometries under mode I, mode II and mixed-mode loadings with consistently accurate results. With respect to the second quantity, an indirect approach is being experimented with. A partially-loaded Griffith crack model is applied to separate segments on the opened crack surface in order to determine the contribution of each segment to the crack-tip stress intensity. The segment contribution can then be distributed along the segment length to give the displacement derivative required.

Research Student: S.W. Ng

CAD FOR FLUID POWER SYSTEMS USING OBJECT-ORIENTED APPROACH

T.P. Leung, W.H. Chan and C.W. Chuen

The Hong Kong Polytechnic University

In this project, an object-oriented model is used to represent the behaviour and the design knowledge of hydraulic power circuits and components. A class reconstruction principle has been derived which enables the class structures of fluid power sub-circuits and components to be defined and expanded in a rigorous manner. In this design methodology, a dynamic module concept will be developed. This object-oriented approach has been demonstrated to be successful in the design of electro-pneumatic sequential control systems. The approach is further extended to the design of hydraulic manifold blocks. In a hydraulic power system, the manifold blocks are usually tailor-made. Computer-aided design of these manifold blocks will facilitate the production of these systems. An object-oriented approach in the design of these blocks has the advantage that

modifications of the component physical dimensions can easily be incorporated into the scheme without difficulty.

Research Student: P.K. Wong

AN OBJECT ORIENTED APPROACH TO VARIATIONAL GEOMETRIC MODELLING FOR MECHANICAL ENGINEERING DESIGN

T.P. Leung and C.M. Wong

The Hong Kong Polytechnic University

In this one year research project, the effect of variational geometric modelling on the representation of 3D tolerance is studied. A 3D tolerance scheme applied to 3D geometrical modelling will be developed for feature based design in mechanical engineering. This scheme makes use of Geometric Tolerance Structure Blocks and their degree of freedom to represent the 3D geometric tolerance in order to establish a reliable theoretical basis for a rigorous, perfect and feature-based tolerance solid modelling in CAD/CAM. The datum coordinate system which can successfully represent the 3D geometry tolerance constraints exerted on mechanical parts will also be established. A method of Tolerance Constraint Topology Graph which can represent intuitively, clearly, and parametrically the tolerance solid model will be developed with B-rep.

INERTIAL EFFECTS IN IMPACT ENERGY ABSORBERS

S.R. Reid and T.Y. Reddy*
(*UMIST)

EPSRC (UK)

Recent theoretical and experimental results obtained at UMIST have shown that under impact loading the mode of deformation and consequently the forces generated in certain types of impact energy absorbing structures ('Type 2 structures', e.g. axially loaded cylinders) and materials (particularly wood) are different from those produced under quasi-static loads. Little previous work has been done on predicting and measuring such forces and assessing the importance of such inertial effects. The project is aimed at devising suitable force measuring techniques using deconvolution to remove the structural response of the measuring system, using them in a series of tests on invertubes, axially buckling tubes and wood loaded along the grain and devising suitable theoretical models to explain the data.

Post-doctoral Research Assistant:
J.J. Harrigan

PROJECTILE PENETRATION OF CONCRETE

S.R. Reid

Magnox Electric plc

Following the publication of a major review on penetration (G.G. Corbett, S.R. Reid and W. Johnson, Impact loading of plates and shells by free-flying projectiles: a review, *Int. J. Impact Engng.*,**18**, 141-230, 1996) Magnox Electric have requested that a feasibility study be made to formulate a research programme aimed at producing comprehensive design formulae for the assessing the threat of missiles striking concrete structures. This is related to the safety and protection of nuclear power plant. Hitherto unpublished experimental data will be collated and used to test existing formulae giving the ballistic limit in terms of the parameters of the impact event. Proposals will be made regarding the improvement of these formulae and the extension of their ranges of applicability.

Post-doctoral Research Associate:
H.M. Wen

PIPE WHIP ANALYSIS

S.R. Reid, T.X. Yu* and J.L. Yang#
(*Hong Kong University of Science and Technology, #Beijing Institute of Aeronautics and Astronautics)

EPSRC (UK) and Magnox Electric plc

The dynamic, large deflection analytical modelling of the motion and deformation of high-pressure piping systems following a guillotine break has been developed extensively at UMIST over the past ten years. This is a safety-related problem associated with nuclear power plant. The model now includes complex bending constitutive relationships which encompass elastic-plastic, hardening-softening-collapse behaviour. The predictions of the theory show excellent agreement with experimental data acquired using high speed photography of tests performed in the UMIST pipe whip facility. The current project involves the development of the solution procedure into a PC-based computer code for use by designers and those concerned with safety assessment. This will supersede the WHIPPIT code based on earlier UMIST work.

PIPE-ON-PIPE IMPACT

S.R. Reid

Magnox Electric plc

A possible consequence of a pipe whip event in a nuclear power plant is the cascading of the failure incident by the whipping pipe striking neighbouring pipes and causing further damage. The project is a feasibility study to formulate a suitable modelling procedure that would allow designers and safety engineers to predict the effect of one pipe striking another, the pipes generally being of different schedules (dimensions). Magnox Electric's own unpublished experimental data will be used to quantify and explain the deficiencies in the current assessment procedures and a programme of research will be formulated which will

be aimed at producing an improved theoretical model.

Post-doctoral Research Associate:
H.M. Wen

APPLICATION OF DAMAGE MECHANICS TO LAMINATED COMPOSITE STRUCTURES

S.R. Reid, P.D. Soden* and S.Li*
(*UMIST)

Defence Research Agency (UK)

Over the past four years a comprehensive damage mechanics model has been developed at UMIST for thin, laminated composite structures for which the main damage mechanism is through-thickness matrix cracks in the laminae parallel to the fibres. This model has recently been embedded in the finite element code ABAQUS and has been successfully applied to the problem of local indentation of a thin-walled filament wound GRP tube. The current research project is focused on extending the theory to include non-linear shear behaviour and other failure modes.

Post-doctoral Research Associate:
C. Peng

IMPACT DAMAGE ASSESSMENT OF COMPOSITE PIPES

S.R. Reid, P.D. Soden* and S.Li*
(*UMIST)

EPSRC (UK) and Oil Industry Consortium

Following extensive experimental studies at UMIST of the effect of radial impact on *100 mm diameter, 4 to 8 mm* wall-thickness filament wound GRP pipes by rigid projectiles of various nose shapes, the critical conditions for leakage and full penetration have been determined for wide range of projectile masses and velocities. Delamination as well as matrix cracking constitute the main damage mechanisms in these thick-walled pipes which allow leakage of the internal fluid. A new model for matrix cracking damage will be extended to include the presence of delaminations in the pipes and the level of damage will be related to the impact conditions and the rate of leakage from the pipes.

METHODS FOR ASSESSING AND PREDICTING LONG TERM STRENGTH OF FILAMENT WOUND PIPES

S.R. Reid, P.D. Soden* and J.N. Ashton*
(*UMIST)

EPSRC (UK) and Oil Industry Consortium

The experimental part of this project will investigate the effects of temperature, pipe wall-thickness and type, magnitude and duration of internal pressure loading on the degradation in the leakage and burst strengths of filament wound pipes exposed to water for long periods of time. The data will provide a test of the existing UKOOA design method for assessing long term strength of glass-reinforced epoxy pipes under simulated service conditions. A new accelerated testing procedure will be developed by relating degradation to the progress of diffusion at different temperatures. Alongside this work, a theory simulating progressive diffusion of water into pipe walls will be developed and evaluated against the test data.

OPTICAL WHOLE FIELD STRAIN MEASUREMENT TECHNIQUES FOR PLASTICITY PROBLEMS

S.R. Reid, T.Y. Reddy* and K.T. Chan
(*UMIST)

Wolfson Foundation

The Wolfson Foundation has funded the building of a new Optical Stress and Strain Measurement Laboratory at UMIST. The facilities in the new laboratory are being developed in consultation with HKPU and several problems have been identified for future collaborative study. These include the examination of the local development of plastic deformation at the root of a stress concentrator (notch or crack) to detect any size effects on plastic yield.

REFINEMENT OF 'REINFORCEMENT 4' – A PC COMPUTER-BASED MODEL FOR COMPOSITE TUBES UNDER BIAXIAL LOADING

P.C. Tse, P.D. Soden* and S.R. Reid
(*UMIST)

Defence Research Agency (initial development)

A computer code for the stress analysis of biaxially-loaded composite tubes based on the equations for a beam-on-elastic-foundation was developed in UMIST. This programme has been applied in successive research projects to a variety of problems involving the internally pressurised composite pipes and vessels and the results have been compared with those obtained from finite element codes. Because of the usefulness of the original programme, it is proposed to amend, extend and refine the original programme to rectify some of the over-simplifications in the original programme and to extend the range of geometries it can treat. The resulting programme will be PC-based.

LARGE DEFLECTION ANALYSIS OF COMPOSITE RINGS

P.C. Tse

The Hong Kong Polytechnic University

A numerical procedure with the capability to account for mid-plane

extension and transverse shear deformation will be developed to calculate the large deflections of composite rings. The strain field and load-deflection characteristic will be investigated by the numerical procedure and experimentally.

Research Student: C.T. Lung

DAMPING AND STRAIN FIELD ANALYSIS OF COMPOSITE STRUCTURES

P.C. Tse

The Hong Kong Polytechnic University

The behaviour of specially orthotropic laminated thin circular rings are studied when subjected to forced harmonic vibration. Formulation of the problem for cross-ply rings is accomplished by a variational principle and the solution obtained by the Rayleigh-Ritz technique. Series of trigonometric functions which satisfy the geometrical boundary conditions will be used to yield a system of simultaneous linear algebraic equations. Solution to this system of equations lead to the displacement and strain fields of the structure. Based on the strain energy approach, a macro mechanical damping model is developed to correlate the pre-determined strain field to damping of the composite rings. The effects of excitation frequency and geometrical aspect ratio on material damping will be investigated.

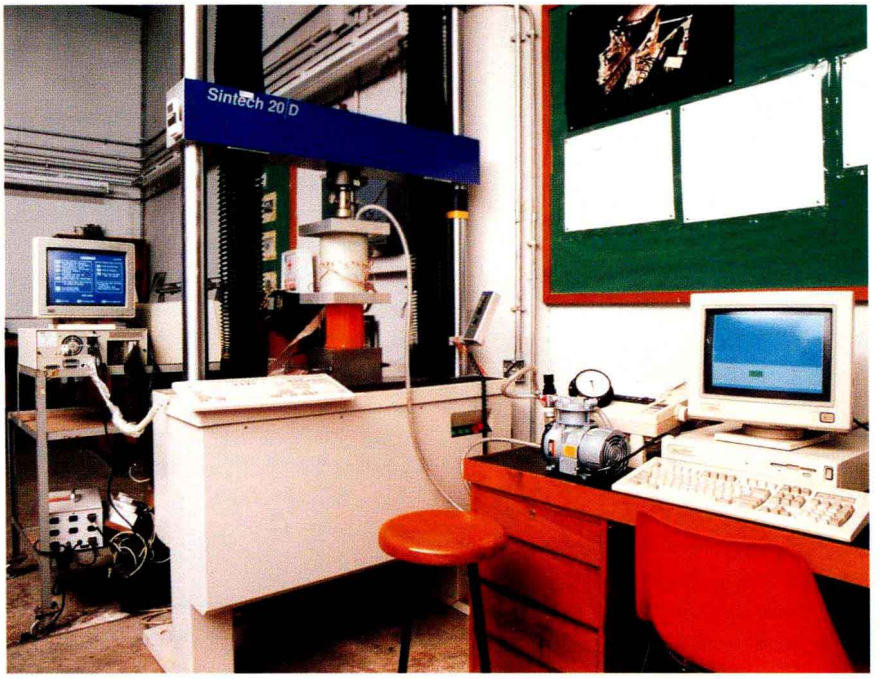
Research Student: W.K. Chan

STRUCTURAL ANALYSIS OF LAMINATED COMPOSITE RINGS WITH ELASTOMER

P.C. Tse

The Hong Kong Polytechnic University

A two-dimensional thin shell theory including the effect of transverse shear deformation is used to find the spring



stiffness, strain energy and strain distributions of laminated composite rings under a compressive radial line load. A series of experiments will be conducted on E-glass fibre woven/epoxy laminated composite rings. The equation of motion of a spring-mass system is formulated to simulate the vibration motion of a composite spring system with an equivalent viscous damping mechanism to simplify the structural damping model of the composite ring. By means of a recursive least-squares estimation technique, the structural parameters of a composite ring with various thicknesses of viscoelastic damping layers will be evaluated experimentally under forced vibration.

Research Student: K.C. Chan

STRESS CONCENTRATION AND FRACTURE ANALYSIS OF PERFORATED WOVEN COMPOSITE PLATES

P.C. Tse and K.J. Lau

The Hong Kong Polytechnic University

Several combinations of perforation and plate width will be selected to provide a range of strain distributions and stress concentrations in order to study the width and hole size effects in perforated woven composite plates. A finite element model for a specified woven composite material will be developed to investigate the fracture behaviour and to obtain solutions for the stress distribution around the cutouts. The hole size effect, free edge effect, stacking sequence, lay-up angle and the fracture toughness of the material will all be examined. Standard experimental methods will be used to investigate the fracture strength and the stress distributions of the perforated plates.

Research Student: S.P. Ng

FAILURE STRESSES OF ORTHOTROPIC COMPOSITE TUBES UNDER BIAXIAL LOADS

P.C. Tse and K.J. Lau

The Hong Kong Polytechnic University

Several combinations of biaxial loads will be selected to generate buckling envelopes by applying combinations of external pressure and axial compressive

loads using a vacuum pump and loading machine. Finite element analysis is applied to implement fracture models and to obtain solutions for the stress distributions in the tubes.

OBJECT ORIENTED SPACE CURVE MATCHING FOR MECHANISM SYNTHESIS

C.M. Wong

The Hong Kong Polytechnic University

This project aims at the development of an Object Oriented Knowledge Based Approach for Mechanism Design. The knowledge, data, function properties and possible variants of a basic component within the mechanism are being encapsulated in different abstract classes. In addition, the relationship and the connectivity of each basic unit are also stored in the Object Oriented Database. The basic components are then composed together to form an abstract mechanism class. Based on the coupler curve pattern matching by backward reasoning, the system can generate the initial configuration of a mechanism. The designer can modify the parameters of the mechanism object. Variations from the designer will then automatically invoke subsequent changes to the path curve and kinematics results, and thus fine-tune the design.

A HYBRID SYSTEM IN PLASTIC MOULD PARTING LINE DETERMINATION

C.M. Wong and T.P. Leung

Industrial Fund by Crown Pacific International Ltd.

This is a MPhil research project. It aims at the development of an efficient computer-aided system in plastic mould parting line determination. This project concentrates on the influences of the geometrical and topological information of the solid modelling of the plastic moulded part which affect the selection of the parting direction and parting line. The shell of a moulded part is decomposed into influential and non-influential features. A local accessibility cone method will be adapted in this project. A local accessibility cone can be considered as the set of half-lines that can locally inspect the entire feature. The accessibility cones of each influential features will be evaluated. The intersection of all available accessibility cones which gives the largest number of intersecting cones will indicate the optimal parting direction. This parting direction minimizes the number of side cores required by the plastic mould. A CAD approach and the related methodology will be developed in an ACIS environment which can support multi-windows and multi-tasks under a PC platform.

Research Student: S.M. Lok

EFFECT OF LASER SURFACE TREATMENT ON ALUMINIUM ALLOYS

T.T. Wong and H.C. Man*
(*Dept. of Manufacturing Engineering, The Hong Kong Polytechnic University)

The Hong Kong Polytechnic University

Substantial savings can be obtained in many types of engineering components through the use of corrosion-resistant materials. This project is aimed at evaluating the applicability of laser surface treatment on aluminium-silicon alloys for the purpose of improving corrosion resistance of such alloys. Samples of aluminium and aluminium-silicon alloys were treated with a 2 kW CO2 laser. Anodic polarization behaviour of laser-remelted samples in different corrosive media will be analysed.

Research Assistant: G.Y. Liang

EFFECT OF STRESS ON VOID-SWELLING

C.H. Woo

Unsponsored

Experimental investigation of void-swelling in fast-neutron irradiated internally pressurized tubes shows significant enhancement, when compared with unpressured tubes. Existing theory cannot explain the large magnitude of the enhancement. We are investigating the effect of stress on the swelling via the lifetime of the primary clusters generated as irradiation damage debris.

ACCELERATION OF IRRADIATION GROWTH IN ZIRCONIUM

C.H. Woo and R.A. Holt*
(*Atomic Energy of Canada, Ltd.)

Partial support from Atomic Energy of Canada, Ltd.

Growth rate acceleration has been observed in many zirconium alloys in a wide temperature range. The acceleration in growth rate is observed to correlate with a gradual increase in the density of c-component dislocations due to the nucleation and growth of basal plane c-component loops. The cause of the acceleration is being investigated and a physically based model capable of describing this phenomenon is being constructed.

STOCHASTIC EFFECTS ON MICROSTRUCTURE EVOLUTION DUE TO RANDOM OCCURANCE OF CASCADES

C.H. Woo and A.A. Semenov*
(*Atomic Energy of Canada, Ltd.)

Partial support from Atomic Energy of Canada, Ltd.

The random nature of diffusion jumps and cascade occurrence results in the

stochastic nature of point-defect arrival at sinks. The influence of such stochastic fluctuations on the evolution of various sink types is investigated. This information is important to the understanding and modelling of microstructure evolution and associated effects, including deformation and embrittlement.

IRRADIATION CREEP DUE TO ELASTODIFFUSION IN HCP-CRYSTALS

C.H. Woo and C.B. So*
(* Atomic Energy of Canada, Ltd.)

Partial support from Atomic Energy of Canada, Ltd.

The elastic strain due to an applied stress produces a change in the crystal symmetry, which in turn changes the intrinsic anisotropy of point-defect diffusion (elastodiffusion). The resulting change in the reaction kinetics between point defects and dislocations induces a stress-dependent and time-dependent deformation in a non-cubic crystal. From the calculated point-defect dipole tensor in the literature, the elastodiffusion tensor can be derived. Calculation of the reaction constants between dislocations and point-defects and the resulting net point-defect fluxes to various types of dislocations yield an irradiation creep rate due to Stress-Induced Preferred Absorption (SIPA). The results will be compared with available experimental data for Zirconium hoping to identify the creep mechanism in this important reactor material.

A NEW METHOD FOR STRUCTURAL TOPOLOGICAL OPTIMIZATION APPLIED TO MECHANICAL DESIGN

L.H. Yam

The Hong Kong Polytechnic University

Structural topological optimization is one of the main subjects in structural optimization design. This research is aimed at seeking a new effective method for higher level structural optimization and to establish its mathematical model which would greatly reduce the difficulties of the problem through converting the discrete nonlinear program into a continuous one. The completion of this research would change the situation of making slow progress during the last four decades in structural topological optimization and speed up the development of the theory for higher level structural optimization and its application in engineering. The engineering application of structural topological optimization to robot, large antenna and aircraft designs, etc., will bring more material savings, economic benefits, and more performance improvements of the products, compared with general size optimization.

Research Associate: K.Y. Li

NONLINEAR ELASTIC VIBRATION OF LAMINATED COMPOSITE SHELLS OF REVOLUTION PARTIALLY FILLED WITH FLUID

L.H. Yam and T.P. Leung

The Hong Kong Polytechnic University

Fluid-filled shells have been used extensively in various sectors of engineering industry, e.g. aerospace, civil, marine, machine, petrochemical, nuclear and power generation, etc. The failure of a partially fluid-filled metal shell due to dynamic loading has received much attention. One of the solutions to this problem is the replacement of conventional metal materials by advanced composite materials. The outstanding specific strengths and stiffnesses of composite materials lead to the high load bearing capacity of a laminated composite shell. The use of partially fluid-filled laminated composite shells in industrial engineering has been steadily increasing. Therefore there is a real need to investigate the free vibration of such shells. The objective of this research is to study the free vibration of a partially fluid-filled laminated composite shell of revolution using a semi-analytical procedure. Displacements and rotations of the shell are modelled by Fourier series and finite elements in the circumferential and meridional directions, respectively, whereas the dynamic pressure of the fluid is modelled by Fourier series, power series and finite elements in the circumferential, radial and axial directions, respectively. Emphasis is placed upon the influence of the filled fluid on the natural frequency of a laminated composite circular conical shell.

Research Student: Z.C. Xi

OPERATIONAL CONDITION MONITORING AND FAULT DIAGNOSIS OF GEARBOXES

L.H. Yam and T.P. Leung

The Hong Kong Polytechnic University

Machine monitoring, fault detection and diagnosis are important and difficult topics in the engineering field. With proper machine monitoring and fault detection schemes, improved safety and reliability can be achieved for different engineering system operations. This project focuses on the condition monitoring and fault diagnosis of gearboxes by using vibration signals. The specific objectives of this project are grouped as follows: fault detection standard studies; fault feature extraction studies, and the application of neural networks to fault diagnosis. Standard spectrums for fault detection will be established through spectral and statistical analysis of vibration signals. Methods for minimizing the cases of false-alarm and miss-detection will be studied. The signal processing techniques based on amplitude and phase demodulation will be developed in this project in order to extract useful information (fault features) from the complicated and noise-modulated raw

signals. The BP neural network model will be adopted to overcome the difficulties of fault identification caused by the non-linear mapping relationship between gearbox faults and features. The approach of this research is universal and can be applied to the condition monitoring and fault diagnosis of a variety of industrial gearboxes and other mechanical systems.

Research Student: P. Yang

MODAL STRAIN ANALYSIS AND DYNAMIC DESIGN FOR VIBRATION STRUCTURES

L.H. Yam and T.P. Leung

The Hong Kong Polytechnic University

Stress analysis of a structure under dynamic load is important in the design of moving machines. Modal Strain Analysis is a new method for estimating strain response directly from the measured force-strain transfer function by means of strain gauges. The stress response can then be obtained accordingly. While in the traditional Modal Displacement Analysis the strains are obtained by the derivation of displacements. This new method can avoid errors induced by derivation, especially at locations where abrupt geometrical changes in cross-section take place. More accurate results can be obtained by this method as compared with Modal Displacement Analysis. The mathematical model and the modal model for response prediction are established. The modal testing techniques and curve fitting methods for modal parameter identification from a strain frequency response function are presented. This project is of wide interest in engineering dynamic design of vehicles, aeroplanes, moving machines, offshore structures and so on. Modal Strain Analysis is a prospective approach to damage detection and machine life monitoring.

Research Associates: DB Li and K.Z. Xue

INTERFACE-RELATED FATIGUE IN FIBRE-REINFORCED POLYMER MATRIX COMPOSITES

L.M. Zhou

Unsponsored

The recognition of the significance of the fibre-matrix interface in composites has led to an enormous effort in both experimental characterisation and micromechanical analysis of the interface in various loading configurations. Most previous work on micromechanical characterisation of interfacial properties focused on fracture processes under monotonic loading. The broad objective of this project is to enhance our existing knowledge of fibre-matrix interface-related fracture and fatigue and to develop reliable means to control the fracture and fatigue in advanced composites which are made from high performance fibres, such as carbon and glass fibres, and polymer based matrices. The project is aimed at developing high fracture-fatigue-resistant fibre-reinforced polymer matrix composites by optimisation of the fibre-matrix interfacial properties. Emphasis is placed on understanding the physics of interface-related fatigue so as to improve the mechanical performance and service integrity of structural components made from these composite materials. The project will provide a theoretical and practical foundation for better design methodologies of composite components for various types of engineering constructions in the fast growing aerospace, automotive, marine, building and sporting goods industries.

Research in Teaching Innovation

TO DEVELOP COMPUTER AIDED LEARNING (CAL) SOFTWARE PACKAGES AS AN AID TO TEACHING ENGINEERING DESIGN AND EQUIPMENT and PRODUCT DESIGN

S.L. Chan

Teaching Development Grant

The present project concerns the development of educational software packages through the use of the latest computer and communication technology. CAL packages will be developed to aid the teaching of design of machine elements in the areas of engineering design and equipment and product design. The learning packages will be concentrated on design and selection of flanges and gaskets and epicyclic gear trains. An object-oriented authoring tool (Authorware Professional for Windows) will be used as a developer. Multimedia and communication techniques will be incorporated into the production of the packages so that the developed packages can be used in the multimedia centre of The Hong Kong Polytechnic University.

PILOT PRODUCTION OF MULTIMEDIA COMPUTER AIDED INSTRUCTION (CAI) PACKAGES ON CD-ROM FOR TEACHING MECHATRONICS

C.W. Chuen and D.W. Yuen

Teaching Development Grant

The project plans writing four CAI packages onto CD-ROM which will be distributed to students as self-learning materials for a number of topics in

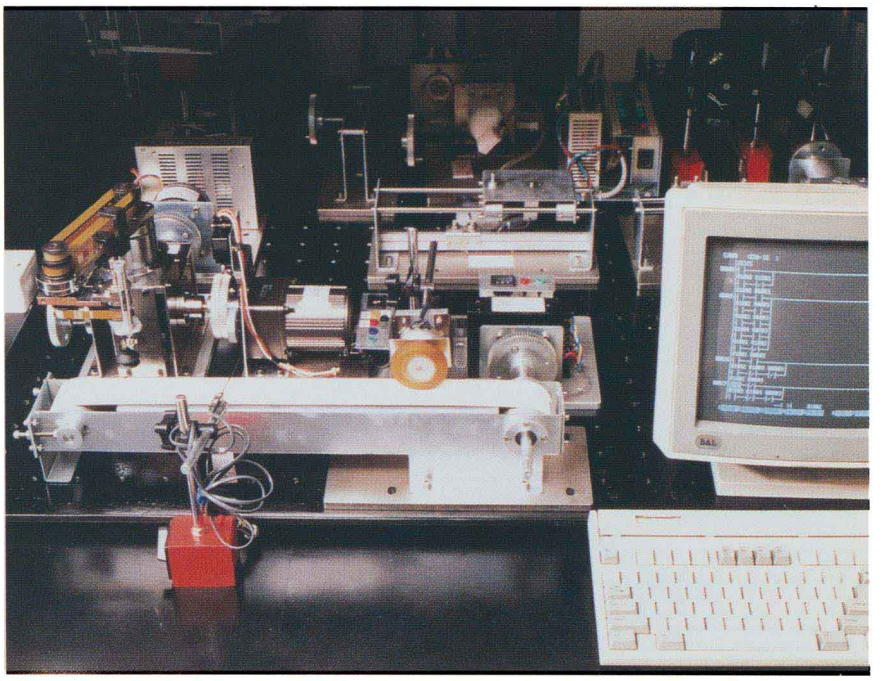
mechatronics. The packages will cover the following areas:

Package 1 : Covers sequential control, Karnaugh map, ladder circuit programming and applications of programmable logic controllers.

Package 2 : Covers fundamentals of computer numerical control, APT and G-code programming, operation of the retrofitted CNC machine in the Control Laboratory.

Package 3 : Covers topics in motors and sensors and the MM-3000 Mechatronics Training System in the Control Laboratory.

Package 4 : Covers topics in robotics, e.g. types of robots, industrial applications.



ADULT STUDENTS IN HIGHER EDUCATION

C.W. Leung, K.P. Kwan* and D. Kember*
(*Education Development Unit, The Hong Kong Polytechnic University)

The Hong Kong Polytechnic University

This project involves a series of experiments and associated analyses to investigate the particular characteristics of the adult students in higher education in learning. Investigations involving questionnaires and interviews will be carried out with students in different disciplines in order to identify their backgrounds, expectations, difficulties, strengths and weaknesses in relation to learning. Investigations will be carried out with two major groups of student, identified according to their ages, modes of study and full-time employment. Academic staff teaching on both full-time and part-time modes of the same courses will also be interviewed in the investigation.

A COMPUTER AIDED INSTRUCTION (CAI) PACKAGE TO TEACH MECHATRONICS USING VIRTUAL REALITY TECHNOLOGY

D.W. Yuen

Teaching Development Grant

The project aims at producing a CAI package on a PC platform which allows students to visualize the operations and motions of various mechanisms and actuators used in mechatronics. Using virtual reality technology, the students can also assemble a virtual mechatronic product, e.g. a photocopier, at his/her own pace. It is expected that the developed package will eventually allow students to design new virtual machines or new virtual mechatronic products using virtual basic components and then walk-through their own designs.

AN EXPERIMENTAL HANDS-ON PROJECT-BASED WORKSHOP COURSE IN MECHATRONICS

D.W. Yuen

Teaching Development Grant

Mechatronics is a design domain but the material is best learned by applying it in the laboratory. Moreover, people learn best by exploring ideas in an informal manner. The course will adopt the project-based approach and students will be provided with sets of predesigned controller boards, predesigned sensors and LEGO Technics building kits and will be given a number of mini projects to do. They will be given the opportunity to take their own ideas from initial conception to implementation, debugging, and applications. In this process, students will learn not only about the technical issues, but also about team work and project management. In addition, they will experience the engineer's satisfaction and exhilaration of bringing one's ideas into reality.