IIT BOMBAY

update

A Newsletter of Industrial Research & Consultancy Centre

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Editorial

IRCC is actively working towards fulfilling the research and development mission of IIT Bombay. Several consultancy and sponsored projects have been offered, agreements signed and distinguished awards given. IIT Bombay has received considerable attention with its participation in various exhibitions and its engagement with intellectual property issues such as the launch of Creative Commons and a WIPO course on Patents.

This issue of UPDATE has fascinating details about recent research developments. We are carrying two long articles on cooperative robots and the nature of high performance within institutions. How do culture and values get institutionalized within organizations? What are the inherent challenges? The article on robots examines in some detail how a dual arm cooperative robot can minimize risk to its employees.

The pages of UPDATE are filled with a series of small articles on several technologies being indigenously developed at IIT Bombay, including, water quality monitoring, hybrid electric vehicle transmission, internet based product design and manufacturing, compact drive mechanism, designing LTA systems and multi-utility heat pumps and plastic solar dryers.

UPDATE will continuously strive to cover new areas of research and development that IIT Bombay is currently working on and share its endeavors with the over ten thousand people and organizations that subscribe to our magazine.

Editor,
Shishir K. Jha

IRCC Notes

Academic institutions the world over are transforming into organizations with greater commitment to innovating for the social and economic benefits of their stakeholders. IIT Bombay has been increasingly focused on delivering research results for the greater society. Today, with the country on an economic upswing and substantial demographic expansion, expectations are on the rise. There can not be a better time to rise up to the task of externalizing its innovations.

As a country, our people are increasingly appreciating the results of home grown research and are sensitized to the need for nurturing an indigenous research culture. As a result, faculty are able to see the tangible benefits of their research, beyond their publications, derived by utilizing various avenues that exist today for maturing their lab-scale explorations into full-fledged technologies. Students see the value-addition from participating in and contributing to faculty research. While IIT Bombay has begun to capitalize on these positive developments, several challenges remain.

Today's problems demand a multi-disciplinary problem-solving approach, especially in areas such as education, healthcare, energy and environmental conservation. Developing solutions for such problems will demand that faculty from erstwhile independent areas, each with its own terminology, research methodology and culture come together, to exploit each other's inherent strengths and research facilities, and collaboratively tackle issues.

For Indian academics, who have historically been relatively more closeted in their own technical areas than their counterparts in the developed world, this would mean a conscious departure from the past. Self-assessment and introspection, along with external pressures as well as incentives are called for. IITB has already put in place processes for the formation of cross disciplinary research groups and for the identification of thrust areas. The highly visible work of the nano-electronics group, involving more than forty faculty/scientists from almost half the departments at IITB, is a laudable example of this endeavour.

For a research institution to flourish, a large multiplying effect must be associated with our researcher efforts. To be fruitful in these efforts we need to ensure that our support systems are at par with our needs. Foremost, this requires that we sensitize funding agencies, especially private ones, to finance beyond the usual, expect more than the obvious, and be willing to entertain risky propositions. Secondly, we need to ensure availability of well-maintained research infrastructure. We need to work in a direction to establish administrative policies and processes that offer reasonable career incentives to well-qualified technical support personnel. As part of this we plan to put in place a number of processes that will help, (a) to intensify fundamental research programs and (b) to identify multi-disciplinary team-based R&D programs with well-defined targets and deliverables.

This issue of Update is appearing after a hiatus. We will now be going back to a semi-annual publication mode to help timely dissemination of IITB's R&D results. As always, we look forward to your feedback.

Krithi Ramamritham

Dean R&D

Prof. Krithi Ramamritham, Department of Computer Science and Engineering and Vijay and Sita Vashee Chair Professor, has been appointed as Dean of Research and Development from 17th July 2006.

Prof. K. Kurien Issac, Department of Mechanical Engineering has been appointed as Associate Dean (R&D) from 4th August 2006.

In Brief

Major New Consultancy Projects

Investigator	Department	Project Title
K M Bajoria	Civil Engg	Expert Advice on Structural Condition of RCC Multistoried Office Buildings
V P Bapat	Industrial Design Centre	Design of Forklift Truck
S Chaudhuri	Electrical Engg	Super Resolution Imaging Applied to Scientific Images
U B Desai	Electrical Engg	Expert Advice in Wireless Communication
D M Dewaikar	Civil Engg	Evaluation of Slope Stability Measures
H Hirani	Mechanical Engg	Design of Mechanical Face SEALS
V Jothiprakash	Civil Engg	Physical Model Studies for Sump Pump
A S Moharir	Chemical Engg	Development of Pipe Leak Detection Application
D B Phatak	Computer Science & Engg	IT Consultancy
S V Prabhu	Mechanical Engg	Two-phase Flow Measurement in a Compact Plate Fin Heat Exchanger
G Sivakumar	Computer Science & Engg	Consultancy Services
S A Soman	Electrical Engg	Assessment of Additional Electricity Transmission System Requirements in India with Reference to Proposed Ultra Mega Power Projects
S A Soman	Electrical Engg	Designing of Specifications for Low Tension Load Management System for Electrical Distribution Companies
S Suryanarayanan	Mechanical Engg	Development of Laboratory for Instruction in Mechatronics
V R Rao/ Mahesh Patil	Electrical Engg	Design and Optimization of High Power MOSFETS

Major New Sponsored Projects

Investigator	Department	Project Title
P Aghalyam/ R D Gudi	Chemical Engg Chemical Engg	Optimisation of the Performance of Integrated Reformer-Fuel Cell Systems
U Bhandarkar	Mechanical Engg	Design and Development of a Process for Nano-Engineered Particles
U B Desai	Electrical Engg	Design and Development of Wireless Sensor Networks for Real Time Remote Monitoring
A De/ D N Pawaskar	Mechanical Engg	Development of Reliable Arterial Models for Large Sized Piping Components Subjected to Fatigue Ratcheting through Finite Element Modeling and Multivariate Optimisation
P Gopalan	Met Engg & Mat Science	Development of Intermediate Temperature Solid Oxide Fuel Cells
A Ganesh	Engergy Systems Engg	Studies in Underground Coal Gasification for Indian Coals
K C Khilar/ S Mahajani/	Chemical Engg	
S Kotha	Chemistry	Application of Olefin Metathesis in Organic Synthesis
S Mahapatra/ J M Vasi/D K Sharma	Electrical Engg	Nanocrystal Flash and Advanced Device Reliability
A Misra / K C Khilar	Director IITB Chemical Engg	Centre for Nanotechnology
K Munshi	Industrial Design Centre	Multi-Purpose Composite Modular Housing System
R Nagarajan	CSRE	Development of Drought Vulnerability Indices for Preparedness and Mitigation
K Narasimhan	Met Engg & Mat Science	Development of Advanced Forming Technologies Towards Manufacturing Light Weight Auto Components
D B Phatak	Computer Science & Engg	E-Outreach: Creation and Distribution of Open Source Content in Engineering and IT
S Sudarshan/ S Chakrabarti/ P Bhattacharyya/ G Nagaraja/ V Apte/ B L Menezes/ K Ramamritham / A A Gumaste	Computer Science & Engg	Laboratory for Intelligent Systems

Select MOUs

Organization	Date Signed	Scope
University of Ulster, Ireland	April 2006	To Promote Co-operation and Research Collaboration in Nanotechnology, Wireless Technology, Network Technology and ICT and Modelling Micro Fluidics
IBM, India	April 2006	Partnership in VLSI Design Research Consortium
IBM-CAS, India	June 2006	Research Collaboration to Develop Technologies and Capabilities of Common Interest
University of Queensland, Australia	June 2006	General R&D Collaboration
Tokyo Institute of Technology, Japan	August 2006	International Co-operation in Research, Education in the Area of Photonics Nanodevice Integration Engineering
Robert R. McCormick School of Engineering and Applied Science, Northwestern University, USA	September 2006	Academic Collaboration in Engineering Research and Education
Kellogg's Graduate School of Management, Northwestern University, USA	September 2006	Collaboration in Management Education
Technische Universitat Darmstadt, Germany	October 2006	Academic Collaboration in Engineering Research and Education
Deakin University, Australia	November 2006	General Academic and Research Co-operation
Korea Industrial Technology Foundation, Korea	November 2006	Scientific and Technological Co-operation
British Gas India Pvt. Ltd.	November 2006	To Promote and Enhance Petroleum Geoscience Teaching and Research
Siemens Information Systems Ltd.	November 2006	Long Term Collaborative R&D Programme
Reliance Industries Ltd.	November 2006	General Research Agreement
CANMET Materials Technology Lab Natural Resources, Canada	January 2007	To Promote Scientific and Academic Co-operation and Interaction in Mutually Beneficial Areas
University of Waterloo, Canada	January 2007	Promotion of Research Collaboration in Science and Engineering
York University Toronto, Canada	January 2007	Promotion of Research Collaboration in Science and Engineering
University of McMasters, Canada	January 2007	Promotion of Research Collaboration in Science and Engineering
National Research Institute of Astronomy and Geophysics, Hekwan, Cairo, EGYPT	March 2007	Scientific Co-operation

Awards

Mr R Ananthakrishnan, research scholar, Department of Computer Science and Engineering, working on machine translation won the second prize at TechVista of Microsoft research India for his work, "Some Issues in Automatic Evaluation of English-Hindi MT: More Blues for BLEU". His research advisors are Prof Pushpak Bhattacharyya, IITB and Dr Sasi Kumar, CDAC Mumbai.

Prof B Bandyopadhyay, Systems and Control Engineering, has been awarded the Fellow of the National Academy of Sciences, for his contributions to propose new algorithm on Multirate Output Feedback based Sliding Mode Control.

Mr Abhijit Badwe and **Mr Vinay Bavdekar**, PhD students, Department of Chemical Engineering, received the IIChE Ambuja Cement Young Researcher Award- 2006.

Prof Jayesh Bellare, Department of Chemical Engineering, has been awarded the Fellow of the Indian National Academy of Engineering for application of the cross-disciplinary, emerging areas of nanobiotechnology, microengineering and ultra-microscopy to a broad range of applications.

Prof Umesh Belur, Department of Computer Science and Engineering, has received the IBM 2006 Faculty Award of $26000 in the area of Autonomic Computing.

Prof Deepankar Choudhury, Department of Civil Engineering, has received the INAE Young Engineer Award - 2006.

Ms Sneha Gupta, student, Department of Metallurgical and Materials Science, has been selected for the Indian National Academy of Engineering INAE Innovative Students Project Award 2006 for her project on 'Nanocrystalline Silicon formation through Aluminium induced Crystillization', with guidance provided by Prof R O Dusane.

Prof Tarun Kant, Department of Civil Engineering, has been awarded the Fellow of the Indian National Science

Academy for his outstanding contributions in developing continuum and discrete finite element higher order shear-normal deformation models for improved response characteristics of multilayered fibre reinforced polymer composites.

Prof Abhay Karandikar, Department of Electrical Engineering, has been awarded the 13th IETE Prof K Sreenivasan Memorial Award by the Institution of Electronics and Telecommunication Engineers in recognition of his contribution to engineering education in communication network and wireless communications.

Prof B P Kashyap, Department of Metallurgical Engineering and Materials Science, has been awarded the Fellow of the Indian National Academy of Engineering for his for his technical and professional contributions in the area of superplasticity and thermo-mechanical processing.

Prof S Kotha, Department of Chemistry, has been awarded the Fellow of the National Academy of Sciences, for his contributions in the area of organic synthesis/synthetic methods.

Prof Pradeep Mathur, Department of Chemistry, has been awarded the J.C. Bose National Fellowship by the Department of Science and Technology in recognition of his academic acheivements.

Prof Ashok Misra, Director IIT Bombay, has been awarded the following: (a) the National Systems Gold Medal Award, 2006, by the Systems Society of India in recognition of his excellent contributions in the field of education, research and development of entrepreneurship activities in the country; (b) the S. S. Bhatnagar Memorial Award, 2007, for his significant and lifetime contribution to the development of science and technology in the country; (c) the Chemtech-CEW Outstanding Contribution Award by the CHEMTECH Foundation for his contributions as a teacher and a researcher for over three decades; and (d) as an Honorary Fellow of Indian Plastics Institute in recognition of outstanding academic achievements.

Dr T R Rama Mohan, retd. faculty, Department of Metallurgical Engineering and Materials Science, has been given Life Time Achievement Award by the Powder Metallurgy Association of India (PMAI) in recognition of his contribution to PMAI in the synergy achieved in bringing scientists, researchers and industrialists working with various particulate materials together under one roof.

Prof N K Naik, Department of Aerospace Engineering, and **Prof Tarun Kant**, Department of Civil Engineering, received the 'Prof H H Mathur Excellence Award in Applied Sciences' in recognition for their work in the areas of 'mechanics of composites materials and structures' and 'polymer matrix composites' respectively. This award is instituted by IIT Bombay alumni Mr Rakesh Mathur.

Prof Krithi Ramamritham, Vijay and Sita Vashee Chair Professor, Department of Computer Science and Engineering, has received the Honorary Degree of Doctor of Science from the University of Sydney, Australia, in recognition of academic eminence, and distinguished creative achievement.

Prof Girish Saraph, Department of Electrical Engineering, has been selected as a joint-winner in the prestigious TiE Canaan Partners Entrepreneurial Challenge for Vegayan Systems, an IIT Bombay incubated company. The event was jointly sponsored by the IndUS Entrepreneurs and Canaan Partners.

Prof H S Shankar, **Prof S Mahajani** and **Prof J Bellare**, Department of Chemical Engineering have been awarded the 'Indira Manudhane Applied Research Project Awards 2006'.

Prof H B Singh, Department of Chemistry, has been awarded the Fellow of the Indian Academy of Sciences, for his significant original contributions to the area of organochalcogen chemistry.

Prof Raghavan Sunoj, Department of Chemistry, has been selected as a Young Associate of the Indian Academy of Sciences, Bangalore for the period 2006-2009.

Prof Chandra Venkataraman, Department of Chemical Engineering, has been awarded the prestigious Vikram Sarabhai Award of 2005, in atmospheric and space science in recognition of her work on aerosol emissions and climate effects in the Indian region.

Prof K V Venkatesh and **Prof Chandra Venkataraman**, Department of Chemical Engineering, have been awarded the 'R. G. Manudhane Faculty Research and Development Excellence Award 2006'.

Prof Pramod Wangikar, Department of Chemical Engineering, has been selected for the 'National Bioscience Award for Career Development- 2006' by the DST, for outstanding contributions in the area of modeling, optimization and monitoring of fermentation.

Events

IIT Bombay Research Paper Award for Year 2005 has been conferred on the following:

M C Deo and **K Thirumalaiah**, Department of Civil Engineering, "River Stage Forecasting Using Artificial Neural Networks", Journal of Hydrologic Engineering 3(1), 26-31 (1998).

H K Pillai and **Shiva Shankar**, Department of Electrical Engineering, "A Behavioural Approach to Control of Distributed Systems", Society for Industrial and Applied Mathematics of Control and Optimization, 27(2), 388-408 (1998).

IIT Bombay Review Paper Award for the Year 2005 has been conferred on:

S Kotha, **K Lahiri** and **D Kashinath**, Department of Chemistry, 'Recent Application of the Suzuki-Miyaura cross-coupling reaction in organic synthesis', Tetrahedron 58 (2002), pp. 9633-9695.

IIT Bombay Young Investigator Award for the Year 2005 has been conferred on:

Prof Anindya Datta, Department of Chemistry and **Prof Pramod P Wangikar**, Department of Chemical Engineering.

Participation of IIT Bombay in Various Exhibitions

IIT Bombay has participated in various exhibitions in the recent past where Research and Development activities were showcased to various audience. These exhibitions were very well received and appreciated by all visitors. The different events included:

- Second Global Conference and Exhibition on India R&D 2006: Mind to Market, inaugurated by Dr A P J Kalam, Ex-President of India, and held at Vigyan Bhawan, New Delhi during 4-6 December, 2006. The event was organised by Federation of Indian Chambers of Commerce and Industry (FICCI) in partnership with the Department of Science and Technology, Department of Industrial Policy and Promotion and The Council of Scientific and Industrial Research.

IIT Bombay along with 28 other R&D establishments from both private and public sectors participated in the exhibition, displaying various technology developments and R and D achievements.

- Exhibition at PAN IIT Global Conference 2006 held in Mumbai during 23-25 December, 2006 showcasing the recent achievements in Science and Technology, inaugurated by Dr A P J Kalam, Ex-President of India.

- Participation in the Science Expo-2006 held at Nehru Science Centre, Worli, Mumbai, during 13-17 January, 2007. This Expo inaugurated by Dr Vasant Gowarikar, Chairman, Rajiv Gandhi S and T Commission, Government of Maharashtra was aimed at high school children and the general public with an endeavour to promote and spread scientific awareness. A variety of exhibits from various departments, schools and centres of the institute were showcased in the form of working models, demonstrations, posters and film shows that highlighted research and technology development efforts and illustrated scientific concepts that would interest students. As part of the Expo, Prof Swati Patankar, School of Biosciences and Bioengineering, gave a popular science lecture, titled 'Biology: The Study of Life'. About 8,000 people, mostly school children, visited the exhibition.

- Participation in Techfest 2007. The annual immensely popular technology festival was held during 26-29 January, 2007 at IIT Bombay. Various events were organized. As a new initiative, a major thrust was given to the R and D exhibition and a dedicated stall was set up featuring some of the R and D breakthroughs along with exhibits from the Royal Society of London.

Short WIPO Course on Patent Drafting

The IPR cell of IIT Bombay organized an eight-day continuing education programme on patent drafting from 10-18 April, 2006 in collaboration with World Intellectual Property Organisation (WIPO).

This programme addressed conceptual and practical aspects of drafting and filing patents. The core skills imparted included drafting of descriptions and claims, compliance with procedural requirements and skills development for working with inventors. The course aimed at building capacity in a field that is critical to IP asset development in India. This workshop targeted participation from academic institutions, Indian research institutes, Indian SMEs, and government funded research organizations.

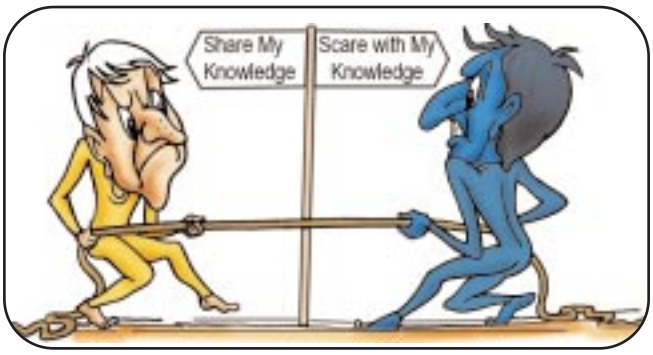
Prof Dipan Ghosh, Deputy Director IIT Bombay inaugurated the programme and the inaugural address was given by Dr G S Jaiya, Director, SMEs, WIPO. Some of the other distinguished faculty included Ms Cynthia Cannady, WIPO, Mr Marcus Englehard, Boehmert & Boehmert, Germany, Mr Tom Ewing, Chalmers University of Technology, Sweden, Mr Sanjay Prasad, IP Value Managemnet Inc., Mr S Majumdar, S Majumdar & Co., Mr R R Hirwani, Head URDIP, CSIR, Pune and Prof (Ms) Karuna Jain, SJMSOM and IPR Cell Coordinator, IIT Bombay.

Launch of Creative Commons India, at IIT Bombay

Creative Commons, India was formally launched on 26 January 2007, at IIT Bombay. Creative Commons (CC) is an alternative copyright licensing system that reserves some rights and waives other rights in favour of the user as opposed to copyright which seeks to reserve all rights by the author.

There were a series of events to mark this significant occasion. There was a formal launch event on 26 January and two parallel workshops conducted on 26-27 January. There was also a stall that provided literature by Creative Commons, India, Creativedot.linux and Novell. Creative Commons, India license is now ready and available for use (creativecommons.org/license).

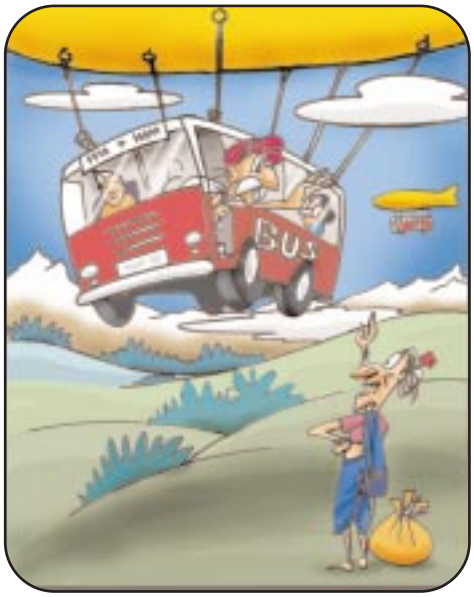
The well attended formal launch on 26 January had the following speakers: Prof Ashok Misra (Director), Mr Joichi Ito (Chairman, CC), Dr Catharina Maracke (Global Coordinator, CC), Prof Deepak Phatak (KReSIT), Mr Nandu Pradhan (President, Red Hat India), Mr Anurag Kashyap (Film maker), Lawrence Liang (Legal Lead, CC, India) and Shishir K Jha (Project Lead, CC, India). Prof Misra gave a brief welcome address. Mr Joichi provided an excellent view of the various dimensions of Creative Commons initiative. He particularly



emphasized the radical opportunities presented by the internet and how the creative community has seized such an opportunity. Dr Catharina provided a view of the CC legal licenses. Prof Phatak spoke out the ongoing work at IIT Bombay that both converges and intersects with Creative Commons. Mr Anurag spoke about the importance of having access to resources for those working in creative areas such as film and documentary making. Lawrence and Shishir provided views about the significance of Creative Commons for India and its importance for the educational community at large.

Design and Technology Development of L-T-A Systems

Lighter-Than-Air (LTA) systems occupy a niche in Aerospace systems owing to their special capabilities, such as the ability to stay aloft even when stationary, owing to the force of buoyancy. Airships and Aerostats are two applications of this technology that are finding increasing application worldwide for many tasks such as aerial surveillance, wireless communication, product promotion, and long endurance high altitude platforms.



Airships provide a low cost alternative for transportation of passenger and cargo in remote areas, where surface modes of transportation are difficult to provide. They do not require long runways and have very low fuel consumption. The operation of the airship produces low noise and vibrations thus reducing crew fatigue and increasing their working efficiencies, especially for low speed long endurance operations such as aerial photography, search and rescue operations and relief operations.

As part of the LTA technology development efforts at IIT Bombay, aerostats and remotely controlled airships have been designed, fabricated and flight tested at various locations in the country. A feasibility study of operation and development of manned airships for transportation of goods and passengers over mountainous terrains in Uttarakhand has been completed.

Subsequently, several study projects in LTA technology development have been completed such as shape optimization of aerostat envelopes from aerodynamic, structural and manufacturing considerations, application of neural networks for design of control system of indoor airships, assessment of technical feasibility of airships as a high altitude platform for precision navigation system.

In an ongoing project, sponsored by One World South Asia, the efficacy of aerostats as an aerial platform for wireless communication for rural connectivity is being investigated. During field trials conducted in May 2007, wireless communication at a line of sight of approx. 7.5 km from the aerostat was successfully established. This system is re-locatable, easily re-configurable, and can be used for providing low cost data and voice communication in remote areas, especially for disaster management.

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Visit: www.aero.iitb.ac.in/~airships

Events & Technologies

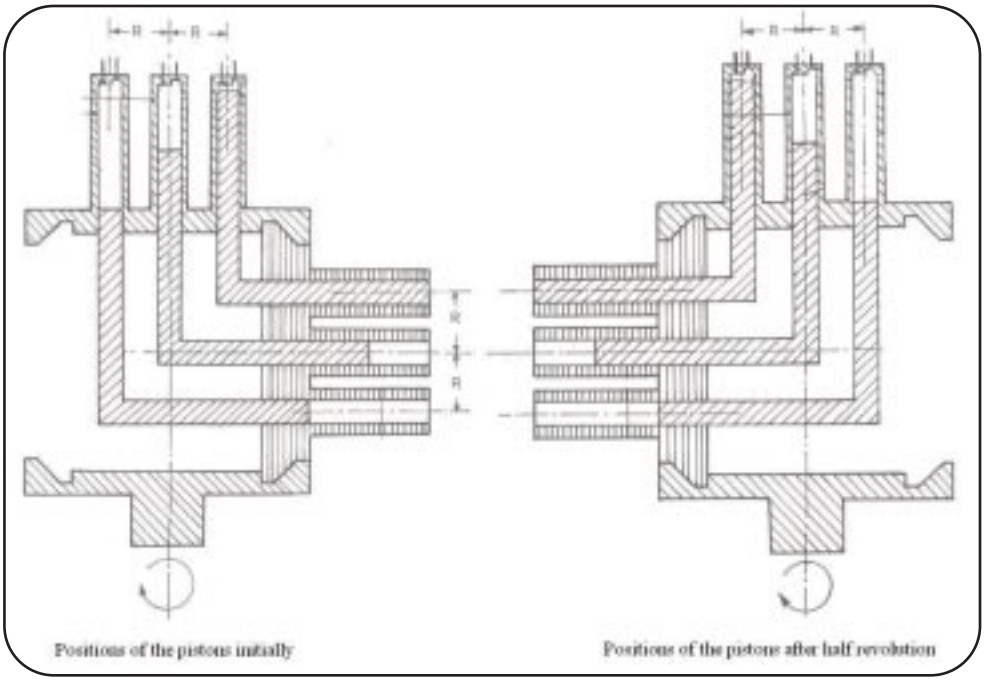
Intellectual Property Day Celebrated

The Intellectual Property Day was celebrated on 26 April 2006 at IIT Bombay. The chief guest and keynote speaker for the event was Dr Gopa K Nair, Ex-President of Indian Drug Manufacturers Association. He spoke on "Research and Other Exemptions under Patent Laws", a topic of relevance to all faculty and members of the IIT community.

Research and other exemptions such as teacher's, are of considerable importance to researchers in academic settings. This exemption also known as the Bolar provision, is an exemption to the rights conferred by patents. Accordingly, despite the patent rights, performing research and tests for regulatory approval does not constitute infringement for a limited period before the end of patent term. Teacher's exemption like 'fair dealing', refers to the extent that academics and students can use intellectual property rights in digital works, web sites, and similar publications that have been created using institutional resources, or which are considered to be topically related to the courses taught or the research undertaken.

A Compact Drive Mechanism of a Reciprocating Machine

By S L Bapat, Department of Mechanical Engineering



An Indian Patent titled "A compact drive mechanism of a reciprocating machine" was granted to IIT Bombay on 5 June 2006. According to the inventor, Prof S L Bapat, Department of Mechanical Engineering, the objective of the invention is to provide a compact and efficient drive mechanism for a reciprocating machine that is free from side thrust.

The utility of this drive mechanism ranges from reciprocating compressor and pump (also vacuum pump) to stirling cycle machines (coolers as well as engines), internal combustion engines and pulse tube cryocoolers. The drive mechanism consists of two horizontal circular discs parallel to each other, both having a coinciding circumferential groove of same size and shape. One of these discs is stationary while the other (driving disc) is rotated using a prime mover. A vertical (driven) disc with external surface matching the curvature of the grooves is placed in between the two horizontal plates. It rotates in the grooves about the central axis of the mechanism and also about its own horizontal axis, which ends up in a planetary motion. This vertical disc has equally spaced circular holes, with same pitch circle diameter through it.

Similarly, the horizontal stationary disc has same number of holes to hold tubes acting as cylinders. Two circular rods are coupled to each other at right angle to obtain a L-shaped member. The horizontal limbs of such L-shaped members are inserted through holes in the vertical disc and the guide sleeve where they rotate and reciprocate and act as load bearing limbs. The vertical limbs act as pistons and reciprocate (and simultaneously rotate) in the respective cylinders mounted on horizontal stationary disc. One rotation of the vertical disc is equivalent to two strokes (one upward and one downward) of each piston. Thus, the rotary motion is converted to reciprocating one using this compact drive mechanism. The drive mechanism enable it to have large stroke to diameter ratio. Moreover, the orientation of the drive mechanism has no effect on the performance of the application for which it is used. The line contact between the mating members ensures least frictional loss. The number of piston-cylinder combinations and angular phase difference between them can be adjusted within the geometrical constraints.

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Technologies

WebNC: Internet based Product Design and Manufacturing System

By S S Pande, Department of Mechanical Engineering

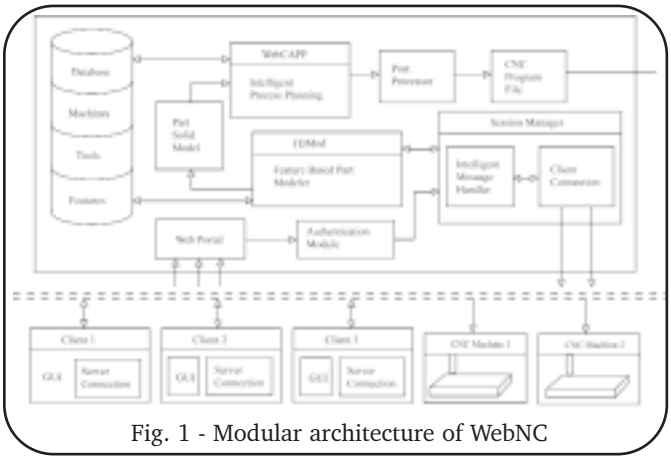


Fig. 1 - Modular architecture of WebNC

Today's manufacturing industries worldwide are facing several challenges such as shorter product life cycles, frequent design revisions, stringent demands on product quality and need for shortest time to market. Product development activities have become customer centric rather than manufacturer driven. Globalization has added a new dimension to this scenario making manufacturers to look for solutions to tap physical and knowledge resources distributed across the globe.

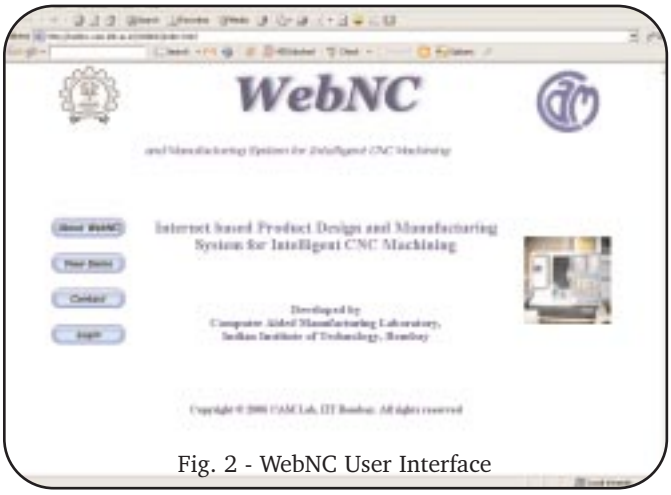


Fig. 2 - WebNC User Interface

During the past five years, the internet has emerged as a powerful tool to enable integration of distributed data to provide collaboration and interoperability. However as of now, internet applications are mostly developed for e-commerce, facilitating communication in the form of transmission of data, pictures and videos. Realizing the potential of Internet, researchers worldwide are attempting to develop network centric CAD/CAM applications for global product development.

WebNC is an internet based product design and manufacturing system indigenously developed by Prof S S Pande and his team at Computer Aided Manufacturing Lab, Department of Mechanical Engineering, IIT Bombay.

About WebNC

WebNC is an internet based software for feature based product modeling and intelligent process planning to manufacture prismatic parts on 3 axis CNC machining centres. It caters to

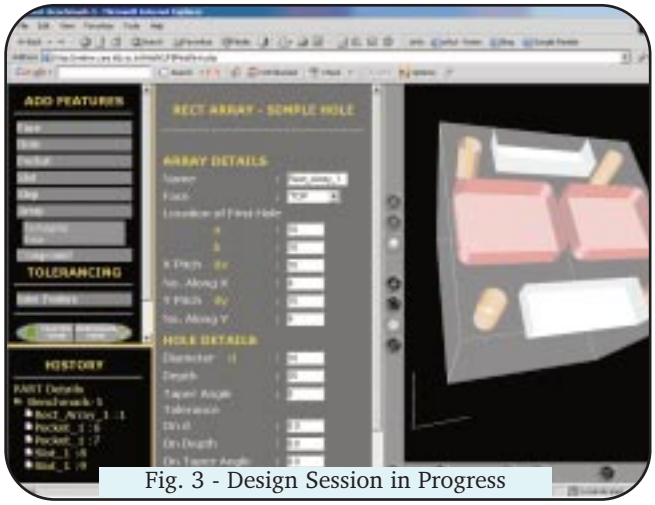


Fig. 3 - Design Session in Progress

part shapes commonly occurring in automobile, aerospace, consumer goods and electric part manufacturing industries. Due to its Client - Server architecture, WebNC can enable integration of globally distributed product designers, process planners and remote CNC machines for collaborative product development and telemanufacturing. In addition it is an excellent didactic tool for education, training and virtual product development.

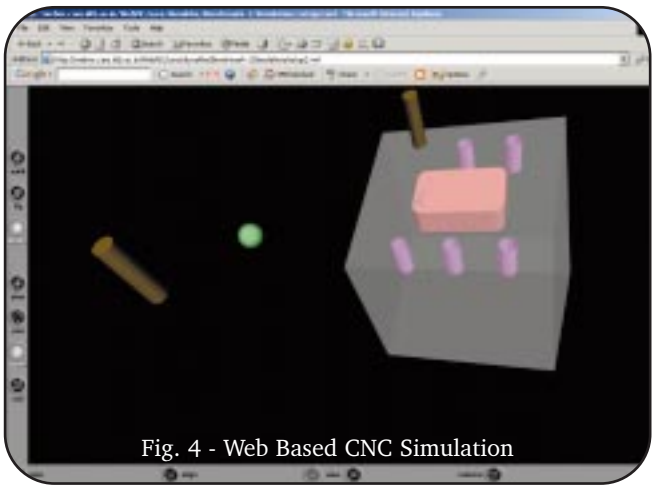


Fig. 4 - Web Based CNC Simulation

Fig. 1 shows the modular architecture of webNC system. It primarily comprises of four functional modules: communication, feature based modeler, intelligent process planning and CNC simulator.

Communication module establishes 'Anywhere Anytime' connectivity between globally distributed users (clients) and CNC machines. Working on Thin Client - Thick Server architecture, it handles issues like user authentication, data transfer and collaboration with remote site CNC machines for telemanufacturing. Fig. 2 shows the User Interface of webNC.

Feature Based Modeler (FBMod) provides a very user friendly graphical part modeling environment to create solid models of parts using design by features philosophy. A rich library of part feature families such as holes, pockets, slots,

steps, array patterns and complex features like freeform surfaces, compound types, derived from actual industrial parts has been provided. Users can easily synthesize/edit/visualize CAD part models using the feature library provided.

Intelligent checks have been provided in FBMod for automatic validation of CAD models based on design for manufacture (DFM) strategy. Users can dynamically view the CAD models during design session using Virtual Reality (VRML) tools. Fig. 3 shows a typical design session in progress.

Intelligent Process Planning (webCAPP) module automatically generates efficient, error free CNC code from the feature based CAD model by performing four functional tasks. These are automated multi-setup planning, intelligent operation sequencing using genetic algorithms, automatic tool and process parameters selection and set up wise CNC program generation. The CNC code is post processed to FANUC and neutral data formats to enable running it on any industrial CNC machine. A customizable tool database has also been provided to suit industrial shop conditions if desired.

CNC simulator (webSIM) provides the user with a virtual CNC machining environment to graphically simulate the CNC code before running it on the machine. Fig. 4 shows typical web based CNC Simulation in progress.

Product Testing

WebNC has been extensively tested from various locations in India and abroad on typical parts taken from actual industrial shops. Part programs generated by webNC were used to cut components on CNC machines. webNC was found to generate optimum, error free CNC part programs consistently. A PC with net connection is sufficient to use webNC. No proprietary CAD/CAM software is required at the user end. This software is available for commercial use by the industries and educational institutes.

Contact: s.s.pande@iitb.ac.in

Visit: www.me.iitb.ac.in/~sspande/

A Novel Hybrid Electric Vehicle Transmission

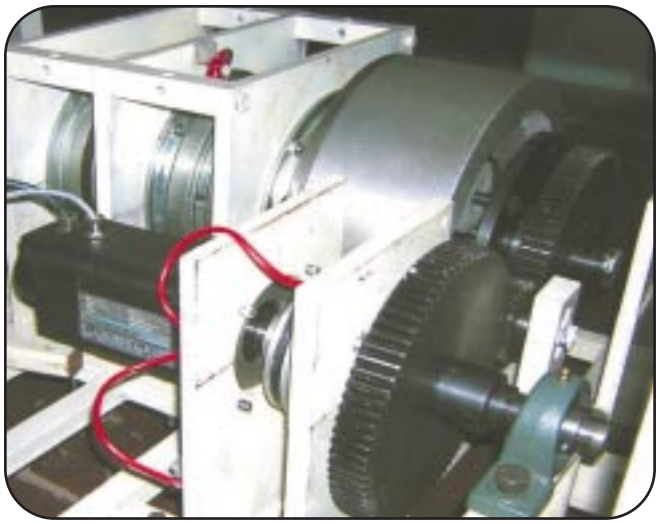
By B Seth, Department of Mechanical Engineering

The sharply rising crude oil prices have put a technical challenge to the automotive sector to reduce the fuel consumption. Automotive business is looking towards electric vehicles to reduce the dependence on oil. However, battery technology development has been found deficient to support electric vehicles. Fuel cell powered vehicles are being sought as permanent solution but infrastructural demands of transporting hydrogen currently cloud their progress. Hybrids assimilation of electric vehicles and current IC engine based vehicles have been shown to reduce fuel consumption by Toyota (Prius, Lexus RX-400h), Honda (Insight, Civic) and Ford (Escape).

The fundamental difference between a hybrid vehicle and an IC engine based (conventional) vehicle lies in their power train. A hybrid uses at least two prime-movers whereas a conventional vehicle uses only one. This implies that the transmission gearbox be able to accept two inputs rather than one that is, it needs to be a two degrees-of-freedom mechanism. Additionally, the gearbox needs to be compact. A planetary gear train (PGT) is the most basic two degrees-of-freedom mechanism. But a single PGT gearbox (as in Toyota Prius) means that the wheels never receive the full torque of the prime-mover, whenever the vehicle is being run by a single prime-mover. A compound PGT with two such basic PGTs interconnected, then becomes a natural solution. However, most compound PGT configurations suffer from a serious problem of recirculating power within the gearing, leading to adverse affect on efficiency of the system and overloading of gear teeth, possibly causing failure of the system.

Technology being offered

The technology developed by Prof Bharat Seth and his student in Mechanical Engineering Department relates to one such compound PGT meeting all the desirable features such as: (a) harmonious addition of the power of both the prime-movers without recirculating power going to disastrous levels; (b) operation of the engine in favourable region of its torque-speed map; (c) a good torque multiplication at low-end speed a characteristic extremely important considering the increasing vehicular traffic density around the globe; and (d) fail safety that allows the vehicle to be operated by any of the prime-mover (operating alone), should the other energy arm of the power train fail for any reason.



Further the transmission mechanism is implementable in real-time, that is, one devoid of any a prior knowledge of drive cycle, scalable, non-myopic (a myopic operation of vehicle misleads into notions of lower fuel consumption based on one round of a drive cycle) and balanced (such that, none of the two energy paths, electric motor and IC Engine, are overloaded at any time, whereby health of both the energy paths is taken care of, at all times).

The engine is connected to the transmission via an auxiliary gear set that lends it the scalability for various types of engines (gasoline or diesel) or for various categories of vehicles (hatchbacks or SUVs). Additionally, this auxiliary gear set ensures that speed longitude (on torque-speed map) in which the engine operates is narrow and is at the lower end of speeds (1200-3000 RPM), a characteristic extremely important for current (as well as those in future) Lean Burn SI Engines and also Common-Rail Diesels.

The augmenting control architecture is simple and real-time since it decides based on measurable quantities such as battery state of charge (SOC), vehicle speed and change in throttle movement. The decision for gear number in next instance is based on state of these variables in this instance, thereby devoid of any a prior information of drive cycle and hence can be practically implemented. The control architecture exhibits negligible increase in fuel consumed for 25 rounds of the New European Drive Cycle (NEDC) compared to one round of NEDC. This implies that the IITB controller is non-myopic. Further, the controller alters the engine torque contribution based on a "SOC-correction factor" which ensures that the battery is sufficiently charged always.

The result of this unison-act of transmission and control architecture gives (for a Tata Indica class of vehicle of 1010 kg mass, co-efficient of drag of 0.25, frontal area of 1.9 m2 equipped with 67 hp, 1.0 L VTEC Gasoline Engine and 10 kW permanent magnet DC motor) a consumption of 2.7 litres per 100 km over New European Drive Cycle. On the US-EPA drive cycle the fuel consumption is estimated to be 3.0 litres per 100 km and on the Japanese 10-15 mode driving cycle the fuel consumption is only 2.3 litresper 100 km over with a maximum speed of 190.5 kmph.

This performance estimates compare well with performance simulated for Toyota Prius. The invented transmission is a generic two degrees-of-freedom transmission and is not specific to IC Engine plus motor hybrids, hence can be adapted on to a two-motor architecture for fuel-cell vehicles. Patents have been filed in India, US and European countries and currently negotiations are on to find a suitable automotive industry partner for prototyping and commercializing the IIT Bombay technology.

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Polysensor - A Sensor System for Water Quality Monitoring

By A Q Contractor, Department of Chemistry

A vast majority of our population does not have access to safe drinking water and this has a significant bearing on their health. In rural areas drinking water is largely obtained from natural sources and these water sources are getting increasingly polluted due to heavy use of fertilizers or excessive drawing of ground-water resulting in high levels of nitrates, fluorides, arsenic or iron. At present, the purity of water can only be tested in laboratories using expensive equipment and highly trained technicians or with chemical test kits of poor reliability. The development of a polysensor aims at providing a low-cost and simple system of testing for impurities in water that can be used by a lay person with a little training.

Parameter	WHO Limit	Polysensor Window	
		Lower	Higher
pH	6.5 to 8.5	5	9
Chloride	< 600 ppm	5 ppm	1000 ppm
Nitrate	< 45 ppm	1 ppm	100 ppm
EC	< 2500 S/cm	10 S/cm	3000 S/cm
Salinity	< 987 ppm	8.5 ppm	1640 ppm
TDS	< 1600 ppm	6.5 ppm	1920 ppm

The system consists of a set of electrochemical sensors and an electronic measuring instrument. The sensors are specific-ion electrodes with potentiometry as the measurement principle. The instrument is battery-operated and portable for field use. The measured contaminant levels are compared with those specified by WHO with a green/red LED lighting up indicating that the sample is potable/non-potable. For a detailed report, there is a 20 char × 4 line LCD display that

reads out the measured concentrations. The sensor-cartridge is screen-printed, low-cost and can be easily replaced.

The instrument is currently capable of testing for electrical conductance, total dissolved solids, salinity, pH, chloride and nitrate. Sensors for fluoride, iron and mercury have been developed while sensors for arsenic and microbial contamination are being developed. With some modifications, the system will be suitable for testing for soil condition and adulteration of milk. It is proposed to develop a system for health-care diagnostics based on biosensors that have been created in IIT Bombay labs over the past fifteen years.

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Multi-Utility Heat Pumps and Plastic Solar Dryers

By M V Rane, Department of Mechanical Engineering

Multi-Utility Heat Pumps is based on patented technology which will help reduce cost of pre-cooling milk, fruits and vegetables while simultaneously drying fruits, herbs or spices. Heat required for low temperature drying is delivered free of cost, while simultaneously increasing the cooling capacity and coefficient of performance of the refrigeration system.

Waste heat from refrigeration units of milk chillers, cold stores and fruit pre-coolers can be recovered using novel patented Tube-Tube Heat Exchangers. These vented double wall tube and tube heat exchangers (Indian Patent # 205 362) enable recovery of the waste heat in a reliable and cost effective manner.

This recovered heat, in the form of hot water at 45 to 60^0 C can then be used in plastic heat exchangers to dry various products. Hot utility can be used to dry agro products to generate additional revenue.

Plastic Solar Dryers are based on patent pending technology wherein, light weight plastic collectors generate hot air to dry fruits, vegetables, herbs or spices. Hot air required for low temperature drying is circulated using PV operated fan for off-grid applications. Grapes, tomatoes, onion, guava, can be dried with the hot air, with out exposure to direct sunlight. Low temperature drying usually results in better quality products resulting in higher value realization.

Benefits

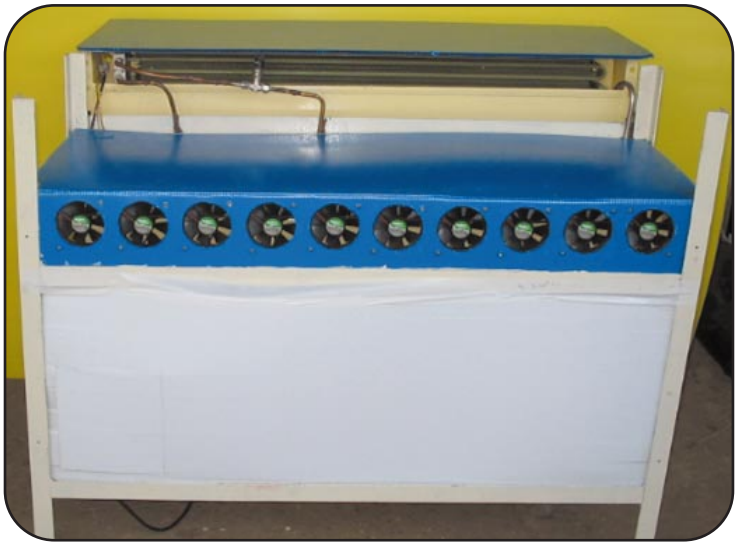
The heat pumps can be used for on-farm pre-cooling of fresh fruits like guava or grapes, while simultaneously drying guava paste or grapes. Pre-cooling is said to increase shelf life by a factor of three, thereby reducing the loss during storage, transport and retail sale.

Distress sale of harvested perishable produce can be avoided with the help of pre-cooling or cold store facility. Economics of pre-cooling and cold store operation will improve significantly due to additional revenue generated from drying. Limited availability of electric power and unpredictability of power cuts can be factored in by incorporating low cost ice bank tank (IBT) or chilled/hot water storage tank/s.

Techno-Economic Viability

The technology of the heat pumps has been tested for industrial, commercial and residential applications. Suitable modifications will be undertaken to meet the needs of the rural applications. Payback period of 0.5 to 1 year is possible for such grid connected robust heat pumps for the rural market.

Plastic Solar Dryers based on novel light-weight high-efficiency Plastic Solar Air Heaters costing about Rs 5000 to 6000/m^2 aperture area can be coupled to efficiently heat ambient air to 50 to 90^0 C for use in dryers. Air in these low-pressure drop solar air heaters is circulated using PV driven fans of 5 to 10 W. These solar dryer can be used effectively used in off-grid locations. Expected payback for drying various agro produce like onions, grapes, ginger, herbs is in the range of 1 to 1.5 years.



There are several lucrative opportunities to benefit from heat pump and solar dryer technologies in our country. Based on survey at the Rahata Block in Maharashtra, INDIA, these systems could be used for milk chilling, pre-cooling guava and grapes; while drying grapes, onion, guava paste, herbs and spices.

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Institutionalization for Evolving a Culture that Promotes High Performance

By Pooja Purang, Department of Humanities and Social Sciences

An analysis of the Best Employers in India by Business Today (anniversary issue January 21 , 2001) found that an important characteristic of successful organizations, impacting their effectiveness, is "living their values". The culture in all the companies studied did not evolve by accident but developed from carefully thought out processes, a conscious set of decisions, work climate and the selection of specific policies and procedures. Best employers also inculcate and reinforce desired behaviour through training and recognition. The above survey identified Infosys as the best employer characterized by 'wealth and values'. Narayan Murthy of Infosys states "The task of the leadership is to make people believe in themselves, the organization, the value system and the philosophy of the organization".

After opening of the Indian Economy in the early 1990s most Indian organizations have written Values, Vision and Mission statements, which inform the customers, employees, external stakeholders and others about their organization values. They describe the kind of behaviour that is met with approval, the policies and procedures that are formulated and practiced, inspiring, guiding and controlling. These statements reflect the values cherished by the top-level management and are usually in sync with the socio-cultural framework in which the organization exists.

The Significance and Components of Culture

Culture provides the "social glue" that generates the "we-feeling", and thereby counteracts the impact of differentiating processes that are unavoidable in a work setting. Organizational culture encourages a shared system of meanings that is the basis for communications and mutual understanding. If these functions of culture are not fulfilled the efficiency and productivity of the organization reduces. Culture of an organization can be understood in terms of the values, norms and artifacts. Values are beliefs of what is good or right for the organization and what should or ought to happen. The stronger values are in an organization the more they influence behaviour. Values are translated into reality (enacted) through norms, artifacts and through rituals, stories and myths. Norms are the unwritten rules that guide (informally) behaviour. They tell people what should be done, said, believed. They are passed on by word of mouth and enforced with reactions in case of violations. Artifacts are the visible and tangible aspects of culture that can be seen heard and felt - the working environment, language in letters, the way members address in meetings or over the phone.

While values are the bedrock of any corporate culture, these must be shared through out the business for it to be value driven. This is not just dependent on mere articulation of values. Implicit values are deeply embedded in the culture of the organization and are reinforced by the behaviour of management, which is very influential. Values that are espoused but not reflected in managerial behaviour may have little or no effect. It's the "values in practice" that guide desirable behaviour and most organizations should avoid discrepancy between what is espoused and what is practiced. If there is a discrepancy it would result in reducing the "we feeling" which culture is supposed to provide. Thus management has to realize that an organizational culture does not develop haphazardly or by accident but it has to be evolved by conscious effort. Values have to be institutionalized to encourage ethical behaviour and develop a culture that promotes efficiency and high performance.

Institutionalization of Espoused Values: Clarity, Leadership and Alignment

This is a process whereby the organization attempts to develop a values driven culture, instill values and go beyond mere stating. There are various steps that have to be given attention to by the organization.

To begin with the there should be clarity and clear communication of values that leaders and employees view as important. An organization's values determine what leaders and other employees will view as important and proper, they provide direction and consistency in decision making in the absence of policy, procedures and precedents. However when an organization attempts to identify its core values it is important to respect the personal value system of the employees, providing them a role in defining and identifying those values. This is important for their perception of ethical congruence, employees should see harmony between what is expected of them and what they personally believe is right.

Company leaders should be personally committed and willing to take credible action on the values they espouse. This creates sharedness of values at all levels, enhancing ethical effectiveness of an organization which is guided and spread by the decisions and actions of its leaders. Leaders pro-

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vide the role models for what the organization requires and expects from the employee body.

Support for ethical practices from the organization has to come from all functions and divisions of the organization. The strategies, goals, policies should emanate from the ethics and value statements of organizations. This support is not always automatic, and therefore, must be cultivated and nurtured by the leader's role modeling.

Ethical Education and Behaviour

Values, policies, procedures, goals and objectives can have a positive impact on performance if employees are trained on the hows and why components of these ethics. This is essential especially in case of new employees who need to be oriented towards what are the acceptable norms and guiding values of the organization. It is through training that employees are prepared to act in their responsibilities for ethical effectiveness of the organization.

In order to clearly demonstrate its commitment to its values and ethical standards, the organization should recognize and reward those values and ethics related decisions that it wants to sustain and promote. In issues like performance measurement, and career development, it should be seen if employees are following the prescribed value system.

There is an underlying climate in every organization, which is an outcome of the employee's collective perceptions about the organization's value, norms and expectations. Perceived congruence between these perceptions and individual (personal) values encourages commitment of the employees towards the organization. Ethically founded and value driven organizations constantly evaluate the impact of values, vision and mission statements, to see their effectiveness in a dynamic business environment and bringing in a change when required.

Relevance of Institutionalization

Focusing on instilling and implementing values helps the organization develop a culture that enhances alignment of personal and organizational values, which is the road map to a high performing work culture. While culture of an organization is intangible but evolving an organization as a value driven one results in tangible gains. This alignment provides a work place to the employee's that fulfills their values, needs and goals and hence enhances their commitment, loyalty and performance. Also following the selection-attraction-attrition process, those employees would be attracted to the organization who would accept the values and culture prevalent in the organization. Those unwilling to accept the culture may either leave of their own accord or can be removed by the organization. Culture is the focus because organizations that support ethical behaviour, strengthen the relationships and reputations companies depend on. Culture is the ingredient that crystallizes other elements of success like excellent products, capable people, modern technology. An organization rich in culture is rich in profits.

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A Dual-arm Cooperative Robot

By Amar Banerji and Ravi N Banavar, Systems and Control Engineering

Introduction

Industrial units that handle hazardous items often feel the need for robotic devices to minimize risk to their employees. Chemical units, bio-waste disposal agencies and nuclear power plants are a few such entities where robotic arms help reduce the risk of injury and infection to humans. An effort in this direction was made by the development of a dual-arm robotic system as a collaborative project between Bhabha Atomic Research Centre (BARC) and IIT Bombay.

In contrast to automation systems, where the task and the product is well defined and routine, a dual-arm robotic system must have reasonable flexibility in the task definition. The ideal system should have the dexterity of a pair of human hands and the intelligence to judge the easiest way to finish a

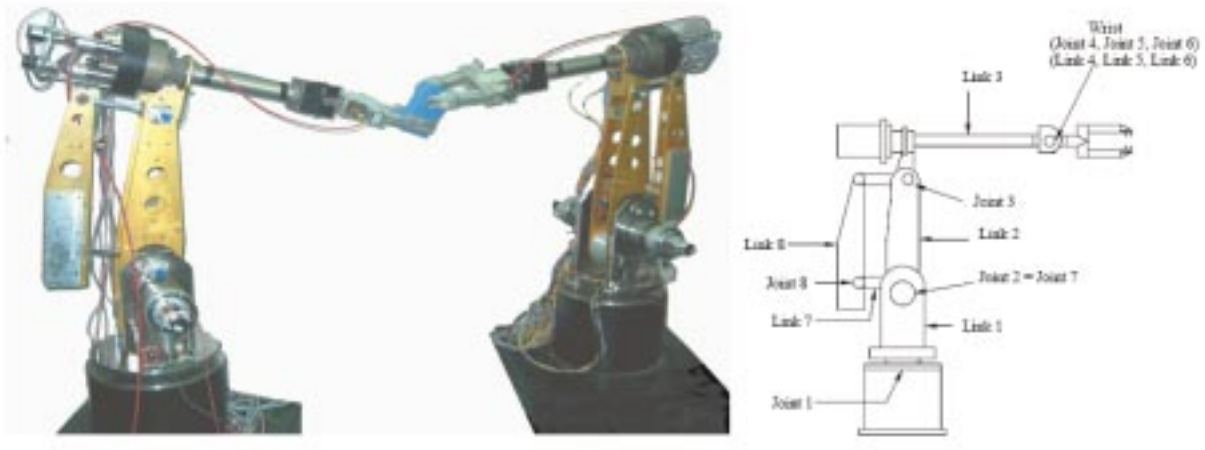

Figure 1: A dual-arm cooperative robot and link-configuration of each robot

Technologies

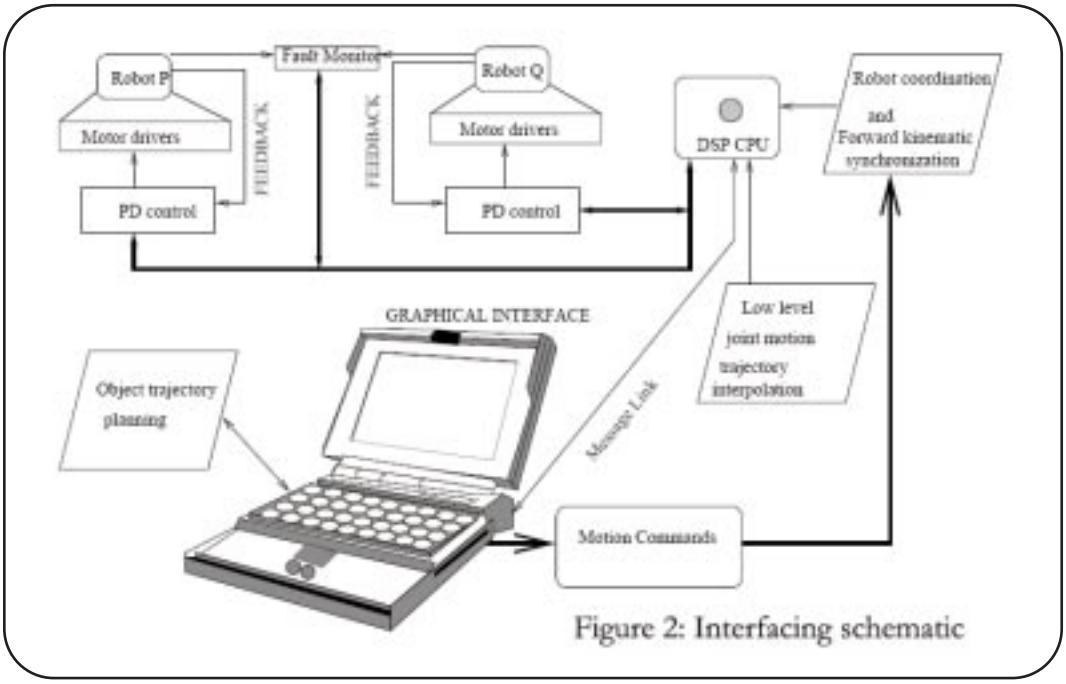

Figure 2: Interfacing schematic

task. A single robotic arm may perform well on routine pick-place jobs but may not be competent to handle complex manipulation like transferring a liquid from one container to another or handling a flexible sheet.

Arm Configuration, Electronics and Interfacing

Each of the pair of robotic arms, (Figure 1) has an anthropomorphic (human type) elbow configurations with six joints. There are three joints at the wrist that support the gripper (the end-effector) and the arm itself has three more joints to position the wrist at the desired location. A parallelogram mechanism is added to the links to provide dynamic balancing and decoupling of the link Coriolis forces. The arms are capable of handling upto 15 Kg weight. The link lengths are 425 mm and 400 mm respectively, giving a wrist reachable distance of approximately 800 mm. The end-effector is presently a fork-type pneumatically actuated gripper. This can be replaced by an instrumented gripper, having a force-torque embedded sensor and controlled gripping movement to handle delicate objects. The end-effector can also be a tool or a sensor to cut and inspect the object, if required. The weight of each robot is about 50 Kg. The complete system with its control hardware requires about 3 meters $\times$ 3 meters space.

The control system (Figure 2) is designed so as to facilitate continuous upgradation and experiments in the hardware. The robots are powered by DC servomotors. The motor control is achieved by a feedback control system based on a PC. These motors are coupled to encoders to generate feedback information. There are limit switches at the joint ends to trip the power supply in the event of malfunctioning. The motors are connected to their respective amplifiers which use Pulse Width Modulated (PWM) signals generated using the output from the PC Interface Card. Feedback from the sensors and limit switches are connected to a PC Interface Card. This card is also like an independent computer. It has one DSP processor with memory modules, D/A converter and EPROM to store data and code. It can communicate with the host computer using an ISA bus. The card has its own program structure that can be used to process encoder data and set different parameters to establish a closed loop control. For simple applications this card has sufficient memory and programming capabilities to be used without any interfacing with a PC.

The PC is used to compute the set points or the desired trajectories of the robots. It is also used to program the interface card's internal code module and set its parameters. The software is developed in-house and the source code therefore, is readily available for improvement and analysis. The pair of robots is easy to operate. A graphical user interface is available to command the robots using the mouse. Alternatively, a pre-planned trajectory can be fed in the form of a data file using the facility in the software.

Research Implications

Tasks such as pouring a liquid from one container to another, pushing a piston into a cylinder or turning the tap of a valve, are few such examples that need two arms to work in cooperation and in synchronism. These tasks, though appear ordinary, call for extraordinary dexterity properties in the robots' workspace. In the case of single arm robots, to avoid the dexterity constraints, the workspace is pre-planned and structured, with pick-up points and placement point positioned according to the task's requirement of desired orientations. However, in the case of dual-arm manipulators, the robotic arms need to maintain the orientation of their end-effectors with reference to each other, either constant or at some desired magnitude throughout their trajectories spanning a large area of their workspace. An example can be given as pushing a piston into a cylinder. In this task the two end-effectors must maintain the same orientation while moving towards each other in order to push the piston. The successful execution of this apparently simple task is surprisingly dependent on many factors such as the length of the travel, the distance between the two robots, initial orientation of the cylinder and joint limits. It is, therefore, essential that the task is carefully planned in the section of the workspace where task specific orientation and location demands are satisfied. The studies on this aspects have resulted in the development of algorithms that makes the planning of the tasks more systematic.

The dual-arm system, developed from scratch, also gives an opportunity to students of various disciplines such as Electrical, Electronics, Mechanical, Computer Science and Industrial Design, to modify, improve, experiment and prove their skills on a working system.

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