



IIT BOMBAY

# update

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Technologies & Strategies for

## Urban Infrastructure Management

- ◆ Reinventing Ayurveda
- ◆ Industrial Mathematics
- ◆ The Process of Language Acquisition
- ◆ Sustaining the Openness of the Academia
- ◆ Hybrid Intelligent System Framework for Business Applications

## Editorial

Although the cover illustration of this volume takes a wry view of it, the urban space of our country is increasingly besieged by a litany of problems which are too real to turn away from laughingly. Of course, as some would aver, it is precisely our "national" ability to live nonchalantly amidst disastrous situations which counts for our "strength". But that also has, or at least ought to have, some limits. While the larger picture of the urban situation is made complex by factors which are economic and political, sound technical solutions are necessary as panacea. The tripartite lead article of this issue focuses on three different aspects of urban infrastructure management: traffic, earthquakes, and flooding. It needs little underscoring that these are proving most taxing to today's urban planners across the world. Several faculty at our institute have been involved with these areas in research and consulting, as well as in providing help for policy formulation. The article presents in a summary fashion, both past and on-

going involvement of the institute in these areas.

Over the recent past, one of the most valuable traditions of the country, *Ayurveda*, has witnessed a steady resurgence. Due to painstaking modern research, it may be on its way of transformation from esoterica to a competitive, alternate form of medicine. Although in a nascent way, a group of faculty at our institute is involved in research on some foundational research on the subject. The related article in this volume takes a "wide-angle" view on the key issues that need to be addressed by the interested research community.

Along with news on various fronts, we also provide a flavour of the range of research work underway at IIT Bombay, such as in mathematics, linguistics, business systems, etc. From an editorial viewpoint, the effort as always, is impressionistic only, and exclusive rather than inclusive.

Sandip Roy, Editor

## Technology Business Incubator at IITB

The Department of Science and Technology (DST), Government of India is currently promoting the establishment of Technology Business Incubators (TBI) to enable incubation of technology based small enterprises in selected thrust areas. It also aims to enhance technological awareness among existing small and medium enterprises. The mainstay of the approach is to utilize administrative and R&D expertise of select academic institutions. As part of this effort, DST has

recently sanctioned a financial grant of over Rs.2 crores to IIT Bombay to set up a TBI on the campus. This is expected to help found start-up companies by exploiting Intellectual Property generated by faculty, students and alumni. TBI will be governed by the Society for Innovation and Entrepreneurship (SINE) at IIT Bombay, a society with functional and financial autonomy.

## Science Expo-2004

In the recently held Science Expo - 2004 at Nehru Science Centre (20-24 November 2004) to commemorate the year of scientific awareness, IIT Bombay was one of the ten participating institutions highlighting scientific and technological advances and concepts. The exhibition was aimed at both school children and the general public.

Several departments of the institute displayed a variety of exhibits in the form of working models / demonstrations, posters, workshops, and film shows highlighting research / technology development efforts and illustrating scientific con-

cepts of interest to students. Some of these included airship models, molecular simulation studies, web enabled cardiac diagnosis using Silicon Locket, Micromouse, Audioogle Search, renewable / alternate energy related demos and models along with various workshops in psychology, GPS / GIS and principles of flight. In addition, a popular science lecture titled *Microsensors: Shaping Modern Lifestyles* was delivered by Prof Rakesh Lal of Electrical Engineering Department. This expo, an endeavour to promote and spread scientific awareness was attended by about 12000 visitors.

## WIPO - IIT Bombay National Workshop on IP Licensing and Negotiation Skills

In way of spreading awareness of the various nuances of intellectual property generation, protection, and exploitation, the IPR unit of IIT Bombay organized a three-day national workshop on 'IP Licensing and Negotiation Skills' during 15-17 November (2004) in collaboration with the World Intellectual Property Organisation (WIPO), Geneva. The aim was to deliberate on the issues relating to the development of competent skills in technology licensing negotiations. The event was financially supported by Ministry of Human Resources Development (MHRD), Government of India.

This workshop addressed some of the issues critical to successful technology licensing as well as technology negotiation. A range of informative presentations were made by the

following speakers: Ms. Cynthia Cannady, Director, Intellectual Property and New Technologies Division, WIPO; Dr. Heinz Goddar, European Patent and Trademark Attorney, Boehmert & Boehmert, Munich, Germany; Dr. Alex H.C.Yu, Director, Innovation and Technology Transfer Office, Nanyang Technological University, Singapore; Dr. Prabuddha Ganguli, Vision IPR; Mr. R.R. Hirwani, Head URDIP, CSIR; and Prof. Kartic C Khilar, Dean R&D IIT Bombay. As part of the programme, a negotiation game was conducted to create a live scenario of licensing options. The event was well attended by officials from both academic and R&D institutions, as well as from the industry.

Patron: Ashok Misra (Director) □ Advisory Board: K C Khilar (Dean R&D) > Rangan Banerjee (Associate Dean R&D)

Editor: Sandip Roy □ Assistant Editor: Padma Satish > Prema Prakash □ Illustrator: Arun Inamdar □ Production: Archana Upendra

## Major New Consultancy Projects

<u>Investigator</u>	<u>Department</u>	<u>Project Title</u>
/// D N Singh	Civil Engg	Advice on Augmentation of Road Infrastructure
/// R Sinha	Civil Engg	Cooling System for Roller Compacted Concrete
/// N L Sarda	Computer Science & Engg	Guidance on ERP Development
/// S K Gupta	CESE	Coastal Zone Management Plan
/// S K Gupta	CESE	Environmental Impact Assessment for Redevelopment of Bulk Terminal into Container Terminals
/// B K Chakravarthy	Industrial Design Centre	Design of Multiproduct Dispenser for Petroleum Products
/// D B Phatak	KReSIT	Advice on Data Warehousing
/// K P K Poopathi	Mechanical Engg	Rapid Casting
/// S Suryanarayanan	Mechanical Engg	Development of Electronically-Controlled Steering Systems
/// S Suryanarayanan	Mechanical Engg	Control of Large Wind Turbines

## Major New Sponsored Projects

<u>Investigator</u>	<u>Department</u>	<u>Project Title</u>
/// M N Kulkarni	Civil Engg	Application of Global Positioning Systems for Meteorological Research
/// G Lahiri	Chemistry	Mixed Valence Aspects of Polynuclear Ruthenium and Osmium Complexes
/// J Bellare	Chemical Engg	Fundamentals and Applications of Nanobiotechnology for Therapeutics
/// M P Desai	Electrical Engg	Fault Simulation Acceleration using Field Programmable Gate Arrays
/// D Manjunath	Electrical Engg	Establishment of a Nationwide Quality of Service Network Test-bed
/// S K Mitra	Mechanical Engg	Enhanced Oil Recovery (EOR)
/// P Gopalan	Met Engg & Mat Science	Ab initio Models for Prediction of Physical Properties of Materials
/// C S Harendranath	Sophisticated Analytical Instruments Facility	Waste Water Treatment and Management

## Select MOUs

<u>Organization</u>	<u>Date Signed</u>	<u>Scope</u>
/// University of KwaZulu-Natal, South Africa	March 2004	Promotion of Academic and Research Cooperation
/// Siemens Information Systems Ltd.	July 2004	Research and Training Interaction
/// Universita` degli Studi di Udine, Italy	July 2004	Promotion of Research and Higher Education
/// Washington University, USA	July 2004	Collaboration in Science and Engineering Research and Education
/// Indian Petrochemicals Corp. Ltd	August 2004	Conduct of Degree Level Chemical Engineering Programme
/// Cummins Diesel India Foundation	September 2004	Setting up of Cummins Laboratory for IC engines
/// Texas Instruments India	August 2004	Enhancement and Promotion of Interaction and Support in the Area of Digital Signal Processing
/// IBM India and CDAC	September 2004	Setting up of a National Open Source Software Resource Centre
/// Intel Technology India Pvt. Ltd.	October 2004	Development of Desktop Solutions on Linux

## Awards

**Prof S Chaudhuri**, Deptt of Electrical Engg, has been awarded *Shanti Swarup Bhatnagar* award in Engineering Sciences for the year 2004 for his seminal work in the area of computer vision.

**Prof D Panda**, School of Biosciences and Bioengg, **Prof V Ramagopal Rao**, Deptt of Electrical Engg and **Prof K V Venkatesh**, Deptt of Chemical Engg, have been selected for the prestigious *Swarnajayanti fellowships* awarded for the year 2004.

**Prof U A Athavankar**, **Prof V P Bapat** and **Prof A Joshi**, Industrial Design Centre have won the award for Certificate of Merit for the Project on "Design of NCR EasyPoint 57i ATM: ASAN for NCR", given under *Consultancy Development Centre National Awards for Excellence* in Consultancy Services-2004 (supported by DSIR Ministry of Science and Technology). The award was presented by the Honourable President of India, Dr A P J Abdul Kalam.

**Prof Ashok Misra**, Director, IIT Bombay, has been elected as the Vice-President of the National Academy of Sciences, India (NASI).

**Prof S Mahapatra**, Deptt of Electrical Engg, has been selected for the prestigious *INAE Young Engineer Award* in recognition of his outstanding contributions in teaching, innovative development and engineering research in Electrical Engg.

**Prof U B Desai**, Deptt of Electrical Engg, has been elected as a *Fellow of the Indian National Science Academy* for the year 2004.

**Prof H Veeramani**, Centre for Environmental Sci & Engg, has been chosen by the Biotech Research Society of India for the *Life Time Achievement Medal Award* for the year 2003.

**Prof K Ramamritham**, KReSIT, has been elected *Fellow of the Indian National Academy of Engineering* for the year 2004.

**Prof T S Rathore**, Deptt of Electrical Engg, received the award the *IETE Prof SVC Aiya Memorial Award (2004)* in recognition of his distinguished contribution in electronics and telecommunication research.

**Prof D Choudhury**, Deptt of Civil Engg, received the *Young Scientist Research Award* from Department of Atomic Energy, Govt of India for the year 2004.

### IRCC Awards

**Dr P K Patwardhan Technology Development Award - 2004** for innovative R&D work was shared by Prof A Karandikar, Deptt of Electrical Engg for "Multiprotocol Label Switching Router" (MPLS) and Prof K G Narayankhedkar, Deptt of Mechanical Engg for "Pulse Tube Cryo-Cooler with Linear Compressor".

**IIT Bombay Research Paper Awards - 2004** were instituted this year to promote benchmarked quality research and publications in the disciplines of Chemistry, Biosciences and Environmental Sciences (Category 1), Physics, Mathematics, Humanities and Social Sciences, Management, Industrial Design and others (Category 2), and Engineering (Category 3). These research paper awards are primarily based on citations by other researchers. Out of the seven awards instituted for top two highly cited research papers in Category 1, top two in Category 2, and top three in Category 3, the following research papers were selected for this year's awards:

- ▶ A new synthetic approach to 1, 2, 3, 4-tetrahydro-isoquinoline-3-carboxylic acid (Tic) derivatives via enyne metathesis and the Diels-Alder reaction, *Chemical Communications*, 503-504, (2000), by S Kotha & N Sreenivasachary, Deptt of Chemistry.

**Abstract:** Various substituted 1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid (Tic) derivatives are synthesized via enyne metathesis and the Diels-Alder reaction.

- ▶ Effects of the intermicellar exchange rate and cations on the size of silver chloride nanoparticles formed in reverse micelles of AOT, *Langmuir*, **13**, 6432-6438, (1997), by R P Bagwe & K C Khilar, Deptt of Chemical Engg .

**Abstract:** Nanoparticles of silver chloride have been synthesized by the method of mixing of two microemulsions, one containing silver ions and other containing chloride ions. The effects of changing the intermicellar exchange rate by varying the continuous phase, by adding benzyl alcohol, and by varying the water to surfactant molar ratio as well as the effect of cations (metal chlorides from the first and second group of the periodic table) on the particle size and the size distribution and the number density have been studied. The particle diameters are measured from the photomicrographs obtained by transmission electron microscopy. The average particle size, the polydispersity, and the number of particles formed are shown to be dependent on the intermicellar exchange rate and/or the rigidity of the surfactant shell. This dependency can be qualitatively explained by means of nucleation and growth phenomena, as mediated by the intermicellar exchange of contents.

## New Research Laboratories / Centres

### Cummins Engine Research Laboratory

The Cummins Engine Research Laboratory was inaugurated at IIT Bombay on 21 October 2004 by Prof. Ashok Misra, Director, IIT Bombay, and John Wall, Vice President, Technology, Cummins Inc. and Director, Cummins India Limited. The laboratory has been set up in collaboration with Cummins India to undertake research on internal combustion engines. The research will aim at developing engines for alter-



nate fuels and address issues such as emissions, noise pollution and cost reduction. Manpower development will be one of the main aims of this initiative. This effort is being co-ordinated by

Prof A Ganesh of Energy System Engg.

Contact: [aganesh@me.iitb.ac.in](mailto:aganesh@me.iitb.ac.in)

### IBM - C-DAC - IITB partnership to set up Open Source Software Resource Centre (OSSRC)

In a move to create a system to further nationwide Open Source Software development, IIT Bombay, Centre for Development of Advanced Computing (C-DAC), and IBM India, signed a Co-operation Agreement on October 6, 2004, to institute an Open Source Software Resource Centre (OSSRC).

With an investment of over Rupees Five crores (USD 1.2 million) expected over the next three years, OSSRC, the first of its kind in the country, will mark the beginning of a series of initiatives to develop OSS activities in India. Under the Co-operation Agreement, IIT Bombay, C-DAC, & IBM would jointly undertake activities to foster OSS development, enhance the understanding of OSS model by imparting quality training. The development of content in areas of education and general awareness of OSS, across the country, will also be pursued.

Contact: Prof G Sivakumar, Head, Computer Science & Engg  
[siva@cse.iitb.ac.in](mailto:siva@cse.iitb.ac.in)

## MPLS Research at IIT Bombay

Multi-protocol Label Switching (MPLS) is a state-of-the-art technology poised to address the traffic engineering challenges in Internet core. The concept is based on simple forwarding mechanism and routing based on quality of service and load balancing. Internet Engineering Task Force (IETF), the standardizing body responsible for standardizing Internet protocols has a group called MPLS Working Group whose charter is to develop standards for MPLS technology. Amongst others, the International MPLS Forums is also involved in accelerating the adoption of the technology. The efforts in developing this technology started worldwide in 1998-99. Today all networking technology developers are actively engaged in creating Internet routers based on MPLS for deployment in core networks of service providers.

**Research at IIT Bombay:** IIT Bombay's effort to develop the technology started in 1999. The objective was to develop an MPLS Router to be released in the public domain as a reference code for technology developers. Today, the complexity of implementing protocols is so huge that most developers start their work using some reference code and then adopt it for their platforms for efficiency and optimization. Standard protocols like TCP/IP have reference source code available. However, in 1999 no such reference code was available. Hence the research focus was on developing a Linux-based open code. Also, the networking community and researchers need an emulator to test the traffic engineering algorithms and protocols for evaluating their performance in actual practice. Hence, it was planned to develop an emulator for MPLS. An emulator is different from simulator in the sense that the former can test actual protocol implementation and accept

live packets from the network.

**Special Features of MPLS from IIT Bombay:** Led by Prof Abhay Karandikar of the Deptt of Electrical Engineering, the MPLS research at IIT Bombay is a complete end-to-end technology development effort which has resulted in a very user friendly interface for a whole range of users. This entire work has been executed through careful and systematic planning of several post-graduate research projects over a period of 3 years. The following modules have been developed

1. *Multi-threaded Label Distribution Protocol, a signaling protocol for MPLS*
  - ▶ Is robust, scalable and capable of extensible implementation
  - ▶ Can automatically capture routing changes on-the-fly and perform corresponding actions successfully
2. *Linux kernel based switching engine for MPLS*
  - ▶ A stable implementation in Linux kernel
  - ▶ Currently supports IPv4 routing
3. *MPLS Emulator*
  - ▶ Can be a useful tool for researchers in networking.
  - ▶ Creates user defined topologies and Label switched paths.
  - ▶ Can also be extended to work as Protocol Development Environment.

Recently, a "Provide Edge router module" has also been added. The entire code along with documentation is available in public domain at [www.ee.iitb.ac.in/uma/~mpls/](http://www.ee.iitb.ac.in/uma/~mpls/) as shareware, and can be used freely.

Contact: [karandi@ee.iitb.ac.in](mailto:karandi@ee.iitb.ac.in)

## City Travel - Mumbai Navigator

Mumbai Navigator is a program which helps plan travel within the city of Mumbai using public buses and local trains.

- ▶ The program takes as input, the starting point of the journey and the desired destination, and generates a plan describing which buses/trains to take, and where to change.
- ▶ The expected travel time including the time spent in waiting for buses/trains to arrive is also provided.
- ▶ The generated plans are adaptive, i.e. they may prescribe a different set of actions depending upon which bus

arrives first while waiting at the stop.

- ▶ Plans generated by the program require the minimum total travel time on the average.

Mumbai Navigator is available to users over the internet at [www.cse.iitb.ac.in/navigator](http://www.cse.iitb.ac.in/navigator). A survey has shown that the program is being used by residents of Mumbai as well as visitors to the city.

Contact: Prof A Ranade, Deptt of Computer Science and Engg [ranade@cse.iitb.ac.in](mailto:ranade@cse.iitb.ac.in)

## A PC based communicator for children with special needs

Based on a concept developed by a teacher and therapist at the Happy Hours Centre, Khar, Mumbai, the Industrial Design Centre, IIT Bombay has developed a special type of foot-operated PC based communicating tool for children with cerebral palsy, or other children with similar difficulties. The product acts as training equipment, but with experience, it can be effectively used as a communication device. The input is through specially developed foot-operated switches, in conjunction with specially developed software to cater to the needs of children who can



neither speak, nor have adequate control over their body movements (except for marginally better control over the leg and toe muscles). The foot-operated keyboard and monitor are housed on sturdy furniture to enable the user to operate it with ease while seated in a wheelchair.

**Upgradation:** The input to the device is now being upgraded by Professor P C Pande, Deptt of Elect Engg, which will give more flexibility in assigning a keyboard as per individual's need.

Contact: Prof GG Ray, IDC [ggray@idc.iitb.ac.in](mailto:ggray@idc.iitb.ac.in)

## National Facility for Texture & Orientation Imaging Microscopy-OIM

A National facility for “Texture and Orientation Imaging Microscopy” has been set up in the Department of Metallurgical Engineering and Materials Science of IIT Bombay with fund support from the Department of Science and Technology under the IRPHA scheme, and additional support from Defence Research Development Organisation and the Department of Atomic Energy on a time sharing basis.

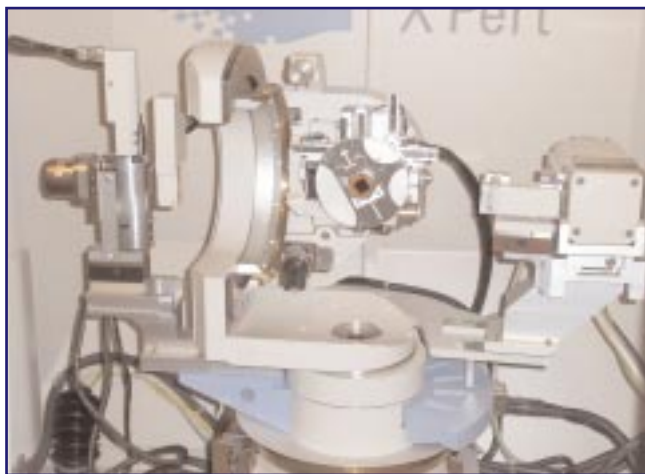


Fig 1: Panalytical MRD system for X-ray texture / stress.

The facility consists of an X-ray texture / residual stress unit (Panalytical MRD system) (Figure 1) capable of accurate



Fig 2: Fei Quanta 200 HV SEM with TSL-EDX OIM system.

measurement of bulk crystallographic orientations or texture and residual stress. The other unit is a SEM-OIM (Fei Quanta 200 HV SEM with TSL-EDX orientation imaging microscopy system for microtexture measurements (Figure 2). Together with the analysis packages, these constitute a complete facility for any in-depth study of crystallographic orientations. The facility is now open to researchers across the country.

Contact: Prof I Samajdar, Deptt of Met Engg & Mat Sci, [indra@met.iitb.ac.in](mailto:indra@met.iitb.ac.in)

## Reinventing Ayurveda

S G Kane, Department of Chemical Engineering

*Ayurveda* or the 'Knowledge (*Veda*) of Life (*Ayu*)' represents one of the outstanding examples of science and technology development in ancient India and is a precious part of our heritage. The three primary treatises by *Charaka*, *Sushruta*, and *Vagbhata* are more than a thousand years old. These and the *Laghu Trayi* provide an elaborate description of symptoms, diseases, diagnostics and therapeutic advice. They also describe the properties and uses of a large number of plants and formulations. There are compilations that cover food technology and describe the preparation and therapeutic properties of a wide variety of general and special foods. Special books even deal with *Ashwa* (horse)-*ayurveda*, *Hasti* (elephant)-*ayurveda* and *Vruksha* (tree)-*ayurveda*.

### Ayurveda: Its Bio-informatics and Bio-technology

As with all modern sciences, *Ayurveda* also has a rich vocabulary which must be properly understood in order to fully benefit from the vast pool of information. Bio-informatics deals with compiling databases, correlating structures with properties, and identifying information structures and patterns. The



*Dravyagunavidnyan* which defines structure and properties of all natural substances of plant, animal and mineral origin forms the primary material database. Besides, several texts and compilations provide extensive information on therapeutic advice (*Chikitsa*) in the form of thousands of multi-herb, multi-functional formulations for every conceivable diagnosis (*Nidaan*). Investigations into the logic of such formulations employing modern bio-informatics tools will certainly provide new insights for future syntheses.

Several *ayurvedic* texts also provide detailed information on product development and effective drug delivery systems. Specific instructions are given on the selection of raw materials, the season for collection of specific herbs, and other quality guidelines for herbal and mineral materials. The formulations can be manufactured in a variety of forms including: *Choorna* (powders), *Asava* and *Arista* (medicated wines), Tablets, *Ghana* (concentrates), decoctions of many types (*Hima*, *Phant*, *Kadha*), *Siddhatailam* & *Ghrut* (medicated oils and ghee), and so on.

A special branch of manufacturing technology deals with herbo-mineral products such as *Bhasma*, *Sindoor*, and *Parpati* etc. These are made from a wide variety of materials including many metals, gems, and carbonate containing minerals. A wide variety of administration routes / techniques are used, including oral, *lepa* (external applications), *nasya* (nasal), *basti* (medicated enemas), etc. A special feature of ayurveda is the use of *anupan*—an adjuvant which may enhance drug uptake, and increase the depth and speed of penetration.

### Ayurveda vis-à-vis Modern Science

Modern science has made enormous strides in the fundamental sciences of biochemistry, pharmacology, molecular & cell biology, and genetics. This has enabled us to target specific diseases even at the gene level. *Ayurveda* in a sense appears to have had a head start in many areas. An *Ayurvedic* practitioner has always talked of medicine combinations specific to an individual. There are descriptions in *Ayurveda* of experiments in *Kayakalpa* i.e. a total reversing of the ageing processes. *Vruksha-ayurveda* describes experiments on how to grow red, blue or yellow cotton which implies an ability to regulate genes for colour producing metabolites. *Ayurveda* also describes *chikitsa* for a variety of metabolic diseases, hormonal regulation, and immune modulation. Yet, both systems are not without their own sets of concerns.

Modern medicine places greater emphasis on the curative over the preventive, and allopathic medicines do have specific performance problems. Apart from drug resistance, side effects and efficacy, major issues are cost and national capability—a fact that becomes significant in today's patent regime. This is something which should be of concern in designing an effective and affordable healthcare policy in a country like ours.

Despite its ancient origins, *Ayurveda* is not really one of the first choice therapies for many, the most important reason being the lack of user-friendly features for today's lifestyle. Many formulations are cumbersome to take and are not readily portable. Dosages are often large and bitter, and medicines need to be taken with specific *anupan* such as milk, honey, *ghee* at specific times. There is a definite perception among many that *Ayurvedic* medicines work slowly and therefore not suitable for acute problems. Most importantly, regulatory systems on chemical and biological quality control which are applied *de rigueur* for allopathic medicines are not yet developed for herbo-mineral and multi-herbal finished products.

### Challenges for the 21st Century

Can Ayurveda be developed as a system for universal, low cost healthcare for humans, animals and crops? To make this achievable, two challenges must be overcome. One is changing the current mind-set of the larger research community, and the other is the technology challenge. The first may be helped by developing courses in *Ayurveda* in regular medical colleges and institutions, and breaking discipline barriers by enabling joint degrees between medical and technological institutions.

The technology challenge, on the other hand, entails producing medicines that are user-friendly (ready-to-use, of

low dose, portable, and with long shelf-life) and of course, low cost. This will require the development of a breakthrough process technology which will reduce the therapeutic dose by a factor of at least 100 or more. The medicines must also be fast acting, suitable for acute problems, and must work on major emerging health problems (diabetes, arthritis, Alzheimer's). In addition, systematic work needs to be done to establish chemical quality criteria for raw materials and finished drugs. Finally, there is an urgent need to develop a wide range of bioassays to assess the toxicity and efficacy of multi-herbal and herbo-mineral formulations.

### The Bhasma Concept as an Advanced Technology Platform

The *Bhasma* methodology is unique to our system of medicine and offers a robust technology platform for future disruptive breakthrough technologies. Though the term appears to signify plain ash obtained by burning a variety of substances, *Bhasma* production is actually a complex multi-step, multi-option process with a diverse array of base materials, process steps, products, and applications. Now, if the desired finished product and the ideal particle size could be identified, it should be possible to develop a modern technology which will take us directly to just the desired finished product, without the use of potentially toxic mercury and arsenic compounds which are present in some *Bhasma* products.

Prof J Bellare, Prof A K Suresh and the author have initiated a research programme for the elucidation of *Bhasma* Technology in the Chemical Engineering Department at IIT Bombay. The first aim is to develop and establish physico-chemical and biological methods of characterization. Such a study would enable the development of a radically different process technology to achieve a greater than 100-fold reduction in dosage. To begin with, methods to determine the elemental composition of the *Bhasma*, the phases, shape and size distribution of particles, and assessment of the coating on these particles need to be established. This will require use of sophisticated spectroscopy and microscopy such as X-Ray Diffraction, X-Ray Fluorimetry, Transmission Electron Micrography, XPS, and also other methods such as Atomic Absorption Spectroscopy, and Dynamic Light Scattering—all of which are available at IIT Bombay.

Starting with one type of *Bhasma*, we have now developed a method for the complete estimation of the elemental composition. We have also made progress in defining the size and the nature of particles. The second part of this work will involve developing bioassays which can be used for batch quality control as well as to test toxicity. *Aspergillus* and yeast systems are being explored as indicators of biological activity, and this is being linked to studies on the activation/inhibition of specific enzymes and other biochemical markers. The work will be further extended to pharmacology and bio-dynamics.

### A New Herbal Technology Option

The author has developed a process technology which can start with any biomass and convert it into a 'super-extract' in edible oil. The extracts display the characteristic therapeutic properties of the base biomass, but the dose required is reduced by a factor of 200-1000. The super-extracts have

been demonstrated to display broad spectrum health-promotional activity in humans, animals, poultry and crops. Work has been initiated at IIT Bombay to screen some of these extracts for anti-cancer activity. Screening work for effect on malarial parasites is also planned. Such efforts will play an important part in validating the super-extract concept.

### What will such work achieve?

The research endeavors presented above will provide not only a validation of current *ayurvedic* products in the market, but also a strong basis for quality control and assurance. The systematic incremental efforts involving elucidation of the structure-activity relationship will provide opportunities to overhaul

the current process technology and to come up with new process concepts for enhancement of activity/toxicity ratio. It is hoped that such work will lay the foundation to extend the "Robust Technology Platform" to other materials, and allow formulation of new products with novel applications. Above all, it will create a strong technology base of international quality and an IPR platform for our traditional knowledge. Dramatic reduction in dosages coupled with speed of response and the depth of response, if validated properly, will provide a revolutionary option for a "User-friendly, Low Cost, Universal Healthcare" in the 21st century in all life science segments.

Contact: [sgkane@vsnl.com](mailto:sgkane@vsnl.com)

## Industrial Mathematics

M C Joshi, Department of Mathematics

Most of the technological processes in industry are effectively described by using a mathematical framework. This framework is used to analyze and comprehend the advantages and disadvantages in adopting efficient and novel methodologies in industrial processes dealing with practical problems—thus introducing "Mathematical Technology." The awareness of and the ability to use this technology is perceived to be essential for modern day academicians and technocrats. The main objective of the Industrial Mathematics Group (IMG) at IIT Bombay is to provide the necessary inputs for Mathematical Technology. The group's vision is to forge long term association between the partnering academic institutions and industry by:

- ▶ establishing study groups leading to a network of national and international institutions
- ▶ designing appropriate mathematical and statistical software for industrial problems
- ▶ disseminating knowledge and information
- ▶ training scientists & engineers in Industrial Mathematics

### R & D Initiatives

IMG's research agenda includes evolution and implementation of solution strategies related to problems in Modeling & Simulation, Scientific Computing, Optimization & Control and Industrial Statistics, and Financial Mathematics. In its research investigations under a DST sponsored project, the IMG has focused on a host of problems: the development of prototypical applications concerning usage of hybrid algorithms involving GAs, and simulated annealing to economic dispatch problems; on-line optimization algorithms for data reconciliation problems in ball bearings; dynamic simulation by DAE for automatic index generation; mathematical model for a chemical reactor at NOCIL; interactive surface designer incor-

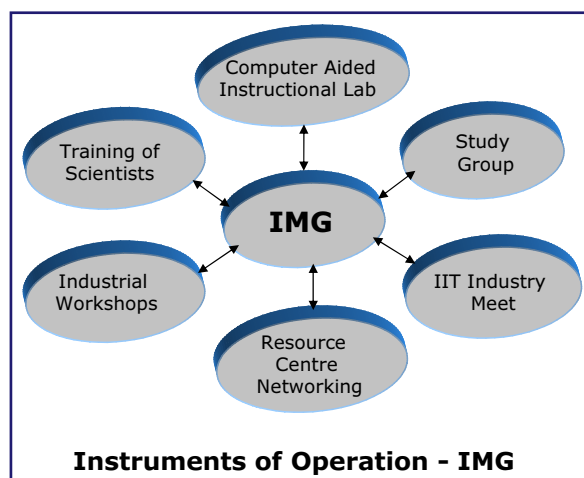
porating newly designed heuristics for convexity; and construction of brand indices using logistic regression and market forecasting. The group's efforts have resulted in viable interaction with possible long term collaboration with several government and industrial organizations.

The current project WEBOPT (Web Enabled Optimization Tools and Models for Research, Professional Training and Industrial Deployment) sponsored by the European Union's IT & C Programme lays emphasis on modeling and analysis for optimum decision making under uncertainty. More specifically, it implements stochastic programming models which combine the paradigm of dynamic linear programming with the modeling of random parameters. WEBOPT also addresses issues related to the provision of optimization tools and decision support systems as distributed applications that are built using Application Service Provision as well as SOAP web services.

Using internet as the underlying channel of communication, the traditional mathematical programming system is split and the components are relocated across the internet

leading to large scale-up in accessibility. Users will be able to use modeling systems like AMPL, MPL, SPInE, and optimizers like FortMP and CPLEX to model and solve industry related problems. It will also be possible to access DSS engines for problems in areas like supply chain management and asset-liability management. Hence, this work is expected to facilitate integration of optimization with Business Process Management procedures—providing a link between mathematics and finance. Other renowned

institutions like Centre for Financial Research, University of Cambridge, and Centre for Qualitative Finance, Imperial College London, are likely to join this venture. (\* *More details at <http://www.webopt.org>*)



**Instruments of Operation - IMG**



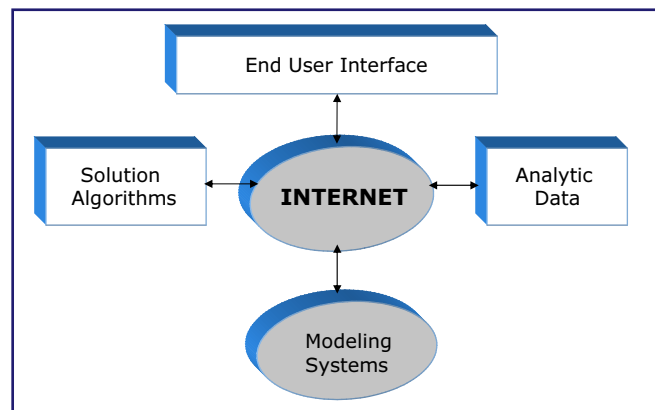
## International and Industry Collaborations

Under the auspices of European Union and UK-India Networking Programmes, IMG is partnering with Oxford Centre for Industrial & Applied Mathematics; CARISMA, Brunel University, UK; Vienna University, Austria; University of Kaiserslautern, Germany; and University of Twente, Netherlands. Under various UNESCO-sponsored schemes, the IMG has initiated steps to help develop Industrial Mathematics programmes at Kelaniya University (Srilanka), and Institute of Technology, Bandung (Indonesia).

The IMG hosts industrial workshops on a regular basis, an activity that has attracted many industrial participants like NRB Bearings, TRDDC, ABB Ltd., Crompton & Greaves, CDAC, Kirloskar Consultancy, ORG Marg, Larsen & Toubro, BARC, ADE and TIL. Seeking the thrust areas for R & D cooperation through the Study Group is a priority with IMG. For example, a workshop on Eco-Modeling was held on February 2000 at the M S University, Baroda. It dealt with dynamic model for salinity distribution in estuaries in Gujarat coast. Recently, IITB and the Plasma Group (BARC) discussed the problem concerning 3D MHD simulation of plasma experiments. A project is under consideration.

The IMG considers a direct meeting between academicians and industrial scientists to be the best means to deal with collaborative projects. Two major meets of this kind were initiated by them. One was in November 1999 wherein IITB - NRB Bearing presented some typical problems faced by their company in the production of ball bearings. The meet culminated into a number of R&D projects. The other was in November 2000, in which IIT Bombay - Central Railway

described the specific problem with wheel breakage incident in recent years. Subsequently, a project presentation was made and an MoU has been considered.



In recent years, the IMG has trained a sizable number of postgraduate and undergraduate students in the area of Industrial Mathematics. The resource generated in terms of Education Technology, Software Development and Infrastructure has been substantial. The group expects to serve IIT Bombay well in realizing its vision of long term partnership with industry.

IMG website: <http://www.math.iitb.ac.in/rd/img/>

IMG Members: Mohan C Joshi, Amiya K Pani, Sanjeev V Sabnis, Sachin B Patkar, Alladi Subramanyam, Suresh Kumar, Amit Mitra (Deptt of Mathematics), Ranjan K Malik, Kannan M Moudgalya (Chemical Engg), K Sudhakar, Raj Kumar Pant (Aerospace Engg) and Harish Hirani (Mechanical Engg).

Contact: mcj@math.iitb.ac.in

## The Process of Language Acquisition: A Case for Innateness

Vaijyanthi M. Sarma, Department of Humanities and Social Sciences

"A human language is a system of remarkable complexity. To come to know a human language would be an extraordinary intellectual achievement for a creature not specifically designed to accomplish this task." - (Noam Chomsky in *Reflections on Language*, 1975)

All human societies have complex language. But what is the *nature* of the human language faculty? Is it specific to our species? What parts of it are built into the design of the human mind? Is it independent of other mental abilities and learning mechanisms? At what point in evolution did natural selection for language occur? The evidence from diverse areas such as linguistics, evolutionary biology, psycholinguistics and neurolinguistics is converging on a view of language as a species-specific ability, and that it is an evolutionary adaptation. Research findings also suggest that the human mind is hardwired for language, and that all languages are expressions of a common underlying *Universal Grammar*. While the insights into the nature of language have been applied to language teaching, parser building, speech therapy, identification of language disorders and language preservation, they tell us primarily about the nature of the human mind.

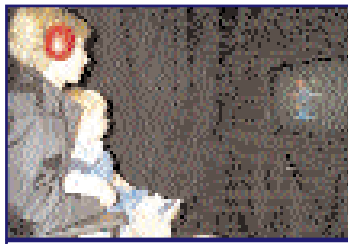
The modern study of languages as rich systems of rules and constraints began with Noam Chomsky's *Syntactic Structures* (1957). His formulation of the problem of language acquisition and his work on 'generative grammar' brought language study (Linguistics) into the area of human cognition.

### Is language hardwired in humans?

Recent research has led to a number of discoveries about the 'design' of the language faculty. Studies of language impairment caused by brain lesions along with neuro-imaging techniques that look at brain functions have identified loci in the brain for grammar, word storage, sound-writing mapping, auditory processing of words etc. These areas are devoted to language processes. For example, in *Pure Word Deafness* (caused by bilateral lesions to the auditory cortices which separate them from a language processing area called Wernicke's area) patients do not hear *words* although they can hear and process non-speech auditory input including music, and can also read, write and speak. In the phenomenon of *Amusia* or *general auditory agnosia*, speech is well-perceived but not other auditory input including music. The area that processes spoken words is thus distinct from the area that processes

other auditory stimuli and neither can assume the functions of the other.

Contrary to the view that language abilities are tied to greater intelligence and more advanced cognition (advanced tool use, art etc.), research has shown that eloquence is independent of intelligence. Children with hydrocephalus (caused by *spina*



*Habituation: An infant learns to correlate visuals with what it hears.*

*bifida* or cleft spine) and William's syndrome patients (caused by deletion of a part of chromosome 7) have low IQs and are considered to be 'retarded'. They are however linguistically fully competent, being able to form grammatical sentences and judge the well-formedness of sentences and words presented to them. The discovery of families with a number of language impaired members who are otherwise 'normal' (a condition called Specific Language Impairment/SLI) shows the converse (see box 1). Work on SLI has led to the isolation of the FOXP2 gene. Though the precise link between the gene and how it determines language is as yet unclear, this gene has changed only twice since the split between chimpanzees and the ancestors of modern humans and the change has been found in all humans, suggesting that it may hold a real clue to the evolution of the language faculty itself.

#### Box 1

Sample utterances of speakers with Specific Language Impairment (SLI):

"The boys eat four cookie."

"Carol is cry in the church."

Sample utterance of a child with William's syndrome:

This is a story about chocolates. Once upon a time in Chocolate World there used to be a Chocolate Princess. She was such a yummy princess. She was on her chocolate throne and then some chocolate man came to see her.

Sample utterances of Genie:

I like hear music ice-cream truck

I like elephant eat peanut.

Want go ride Miss F car

As most of us who have any experience of learning a second language post-adolescence know, language learning is not easy. 'Accent' is the most obvious manifestation of this degradation in ability. In a recent case Genie – a 'feral' or a 'wild' child – was denied linguistic and parental contact by pathological parents (*Genie: A Psycholinguistic Study of a Modern-Day "Wild Child"* by Susan Curtiss 1977). After her 'discovery' at the age of 13 she was unable to 'learn' to produce grammatical English sentences. Children who sustain damage to the language (left) hemisphere show remarkable recovery of language, but only until early adolescence. These cases show us that there is a *critical period* for language acquisition and that language is subject to biological maturational parameters.

First language acquisition research has provided greater insights to the nature of language and its mental organization. All children converge rapidly upon the gram-

mar of the language(s) that they speak by the time they are 3 years old. This task is by no means simple. Children have to (a) tune into the sound units of the language, (b) map arbitrary sound sequences to meaning (word learning) and (c) induce how these words are put together to create sentences. Experimental work on prelinguistic infants (that relies on infants' responses such as showing boredom by looking away or stopping sucking and increased interest by looking or sucking) have shown us that they are sensitive to speech as compared to non-speech, to sound categorization (the difference between [p] and [p<sup>h</sup>] and [p] and [b] etc.), to syntactic frames (such as the difference between verbs with one object such as 'buy' and verbs with two objects such as 'give') etc.

A child creates language even when the input (what s/he hears) is severely deficient. This is shown by work on *pidgin* and *creole* languages. Pidgins are grammatically deficient contact languages. Children who are exposed to pidgins as their only language input will nonetheless develop a grammatically whole and 'normal' language (with word order, tense marking, embedded clauses etc.) called creoles. The same phenomenon is seen with sign languages that begin as pidgins in school backyards and are transformed into creoles by young signers. The material for the grammar is certainly not present in the input and must come from the children themselves. This appearance of rules offers a remarkable picture of the linguistic mind. In fact, the study of sign language has shown us that the elements of mental grammar are preserved even when the mode of communication changes. In spoken languages meaningless sounds combine to form words and words combine to form sentences. In sign languages, meaningless units of hand-shape, location and movement combine to form individual signs that are then combined to form utterances. This fundamental design property of language called *duality of patterning* makes it possible for language to produce an infinite output from finite sets of sounds and rules.

#### Box 2

Learning without explicit instruction

Child: My teacher holded the baby rabbits and we patted them

Adult: Did you say your teacher held the baby rabbits?

Child: Yes

Adult: What did you say she did?

Child: She holded the baby rabbits and we patted them.

Adult: Did you say she held them tightly?

Child: No, she holded them loosely.

Finally, children produce 'ungrammatical' forms that are never heard in the input (such as 'goed', 'bleeded', 'bited') and yet never utter plausible ungrammatical sentences that are analogous to what they hear around them. Upon hearing sentences like 'Is he good' and 'he is not good' (from 'He is good') no child says 'Read he something' and 'He read not something' (from 'He read something'). In fact, research on language acquisition has shown that caregivers seldom instruct children on grammatical incorrectness, and more usually only for information correctness or social appropriateness. Children converge on the grammar with all its com-

plexities without explicit instruction (see box 2) or even conclusive evidence. This cannot be accomplished without an innate predisposition to acquire language.

### Research at the Infant Language Laboratory, IITB

In collaboration with the University of British Columbia, we are looking at the process of early word building in 12-20 month-olds. It has been established by Prof. Janet Werker (UBC) and her colleague Prof. Tees that during the first year of life, infants tune into to the sound system of their native language. At around 6-8 months of age they can discriminate between consonants, even those not used in their native language. Infants exposed to English and those exposed to Hindi can both discriminate between [p] - [b], [b] - [b<sup>h</sup>] and [p] - [p<sup>h</sup>]. This ability to discriminate between non-native categories (such as the difference between [b] and

[b<sup>h</sup>] and [p] - [p<sup>h</sup>] for infants learning English) declines by 10-12 months of age. Since the mapping between sound and meaning is arbitrary and must be learned for each language, might these perceptual categories help determine word learning? What are the conditions under which infants can learn to link labels with objects including very similar sounding labels such as "bin" and "pin"? To investigate these and other related questions, we plan to test infants growing up in very different language environments - English and Hindi and/or Tamil - to study the effects of experience on perceptual and language development. In addition, we also plan to set up an acquisition database of both monolingual and bilingual children with recordings of natural speech to enable us to consider grammatical issues in language acquisition.

Contact: vsarma@iitb.ac.in

## Sustaining the Openness of the Academia

Sandip Roy, Department of Chemical Engineering

The sharp ascendancy of the market forces in the global order has changed the ambience within which "old-world" public institutions are expected to function today. The signs are most dominant in the social sectors where there has been a gradual retraction of many national governments from pursuing more public-spirited policies. The fallout: a growing conflict between the private and public interests, between individual and community-oriented values. Historically speaking, the academia has been one of the strongest public bastions. With the gradual encroachment of the market "ethic" in the academia – strongest so far in the US universities – and the possibility of its world-wide emulation, there is a need for greater introspection about the long-term repercussions of the phenomenon.



At the heart of the conflict lies the fundamental divergence between corporate culture and the traditional academic values. While the former thrives on competition, strategy and performance (as profit), the academia cherishes autonomy, exploration and process. In a world where, increasingly, the arbiter of achievement is monetary, the academia may find its values challenged to a significant degree in the times to come. However, the response does not need to be a head-on encounter; whose efficacy anyway seems doubtful today. The resolution of the challenge may lie in identifying the real threats of the conflict as well as a rational defense of the *intrinsic* worth of academic ideals.

### The Academia as the "Commons"

In essential terms, the difference between the academic and corporate values may lie in their respective interpretations and use of the knowledge that is continuously garnered through human *exploration* and *analysis*. While business may hunt out that which is clearly utilitarian and capable of generating commerce, the academia has treated knowledge much less as a

*commodity*, and more as a natural outcome of a continual, shared human enterprise. Probably the most eloquent description of that came from Newton himself: "If I see farther than others, it is because I stand on the shoulders of giants." Jonas

Salk, one of the pioneers who developed the polio vaccine in the 1940s had once been asked who owned the patent for the discovery. The answer Salk provided was terse but deep: "Well, the people. There is no patent. Could you patent the sun?"

Rooted out of its context, such a view may appear grandly idealistic today. But beneath the surface of it lies a humble recognition of a plain truth: that the creation of human knowledge never is or can be an individual enterprise. The reason for it is simple enough: no single group of people, let alone an individual, is solely endowed with the powers of reflection and creativity. The expansion and validation of knowledge are possible *only* if it is built upon that created by past as well as contemporary generations. The unspoken ethic is that anyone is free to build upon the work of other members of the community without any monetary exchange. The vitality and self-generative powers of human knowledge derive from treating it as a common social resource: open and shared. There is no doubt that historically, this has proved to be a natural and a productive route. In today's world, technology has enabled newer, potentially no less powerful approaches: collaborative websites, newsgroups, open source software communities, online archives and so on. In the times to come, the use of internet-based research communication and peer-networking could be the most potent devices to sustain and uphold the public nature of human knowledge.

The market approach to creation and use of knowledge is quite the opposite. Based as it is on private interests, the market ethic, is naturally possessive; hence closed and

divisive. Under such conditions, the attitude of trust, openness and sharing so effective in the academic domain, can transform into an unproductive "strategy". However, the argument is not meant to be a wholesale critique of the markets. Without the intervention of business, it would not be possible for the academia to reach the fruits of its research to the larger society. The intrinsic efficiencies of the markets in aiding generation and diffusion of wealth within societies cannot be buried by simple ideological polemics. It can be also an effective instrument in managing physical resources of the world in an optimal fashion. But whether it can also prove an equally successful apparatus for managing a far *less tangible* entity such as human knowledge is far from proven.

Indeed, the market ethic appears innately antithetical to the community-oriented values that form the bed-rock of the process of accretion of knowledge. The measure of value here is relatively uni-dimensional: price. This is necessarily simplistic in that it does not adequately recognize the more complex, emotive aspects of human creativity. And that the worth of, or reward for a creative work does not have to be based on its transactional potential alone; rather it may be founded upon less tangible elements such as recognition or fame within a community. The more public process of generation of knowledge perhaps also recognizes and fulfils a deeper human need: to belong to a community cemented by an ethic of sharing and collaboration.

### Resolving the Conflict

The permeation of the market ethic into the academia today is evident in the enhanced accent on activities such as: patenting, technology transfer, incubation and entrepreneurship. There is no doubt that these mechanisms can help research inventions provide greater social benefits. The recent experience of a number of US universities in particular, in reaping the financial benefits of technology licensing appears impressive.

Nevertheless, averaged across the entire university system royalties form a little over 2% the annual R&D expenditures today. In addition, the costs of maintaining the inventory of patents and according them legal protection amount to more than 10% of the royalty. There are natural concerns if the process of supplanting public funding of academic research with private finance can be a sustainable one.

There is a host of other complex issues that academia and the society as a whole may need to confront. Who primarily owns and derives the benefits of public funded research? What mechanisms need to be in place to ensure wide affordability of products whose invention is supported by tax-payers money? How does the academia ride the ongoing changes and yet retain its public spirit, and independence from business compulsions? What would be the eventual outcome of a possible deadlock over such cultural differences?

The answers to these questions and many others are not likely to be simple. Besides, it would be naïve to ignore the link that is necessary between the academia and the markets in furthering economic betterment of societies. The debate needs to attain greater clarity on the essential nature and *purpose* of the two entities and the policies needed to sustain them. It may neither be possible nor desirable today to reverse the structural changes that the academia is undergoing in integrating with markets. Perhaps, the way forward lies in a deeper appreciation of very nature of production of knowledge, and that it is far less amenable to commodification than physical assets. The most optimal way to advance knowledge may still be in allowing its widest possible sharing, in retaining its public nature. Knowledge and creativity that are strictly controlled cannot mature. Openness may alone be the most efficient engine of its growth.

Contact: [sr@iitb.ac.in](mailto:sr@iitb.ac.in)

## A Web-based Hybrid Intelligent System Framework for Business Applications

Rajendra M Sonar, Shailesh J Mehta School of Management

In today's competitive business world, capturing new customers and retaining them is a challenge. To bring efficiency and cost advantage, organizations not only have to intelligently manage their resources, but also the expertise available within. While analytical tools help managers in making decisions, they do not give support in accumulating and managing precious expertise available in the organization. Intelligent systems are best suited for this purpose as they help to extract, acquire, represent, preserve, use and apply *knowledge* in numerous domains. The widely used intelligent systems in management are expert systems (ES), artificial neural networks (ANN), case-based reasoning (CBR), fuzzy systems and genetic algorithms (GA). These differ in ways they acquire, process, and apply knowledge. Each system has its inherent weaknesses and strengths, which makes effective problem-solving difficult using a single technique. For example, while expert systems cannot learn and adapt, they are good in giving qualitative explanations and justifications for

the decisions they make. Conversely, neural networks are good at learning and adapting but poor in explaining their results. Combining these techniques enhances their overall strengths and lessens weaknesses, and allows solving a problem in an effective way. A given problem can be solved better by using even more techniques, and results compared to make better decisions. For instance, while evaluating a new borrower, the details of the loan application can be fed to an ES, ANN, as well as CBR system (see box). A manager can compare the results of all these systems to make a final evaluation of the borrower based not only on expert opinion (using ES), but also on experiences with past customers (using ANN and CBR). The case-based reasoning system goes further by predicting how the new borrower will behave (repayment pattern) once the loan is approved, based on past experiences with similar borrowers.

### Decision-making and Smart Websites

Web-enabled managerial decision-making and knowledge-

### Definitions of some Intelligent Systems

**Rule-Based Expert System:** It is a system that acts as an expert consultant by storing *knowledge* and using it intelligently. Knowledge consists of the *facts* (data about the problem to be solved) and a set of rules to solve the problem. In the Q & A mode, the expert system works like a doctor asking a series of relevant questions (to know symptoms) and gives expert opinion (diagnosis) based on answers (symptoms).

**Case Based Reasoning:** A CBR system contains repository (case-base) of solved problems (cases). It retrieves hidden expertise in past cases and uses it to address a new problem (problem case). It recommends a decision by re-using and adapting decisions made in prior *closely matching* cases.

**Artificial Neural Networks:** They simulate the working of biological nervous systems. When trained to solve a problem by providing past data, they *learn* complex relationships and patterns in it. Holding this as implicit knowledge, they use it to solve new problems.

**Genetic Algorithms:** They are algorithms based on the Darwinian principle of *survival of the fittest*. Using nature's principles of *selection* and *evolution*, they quickly and effectively find a reasonable solution to complex problems. They are well suited for applications like optimization.

based systems can render decision-making an objective, reliable, and *centralized* activity. Such centralized systems help to make decisions under the broad policies, objectives and constraints of an organization as a whole. It accords the management a stronger control on the overall process. Business and decision rules can be managed or changed easily and there can be substantial improvement in workflow.

Although abundant information is available on websites, a visitor often wants specific information and customized answers rather than reading and evaluating numerous web pages—an activity that requires skill in searching for the right information. The need therefore arises for a website with an expert interface that can intelligently guide the customer towards the required information. Such dynamic delivery needs websites to be capable of engaging customers through a series of questions and answers in user-friendly language, just as an intelligent sales person would. Unlike the keyword search where a user may get a "no match found" answer, the intelligent search (expert guide) understands the *objectives and goals* of customers instead of the exact product that they want. Smart websites can save on call center costs and provide self-service facility to customers rather than assisted-service. Instead of giving static interface based on predefined queries, browser-based kiosks or computer terminals connected to these smart servers can give expert advice to customers on their specific queries, and information related to products and services.

### Research Initiatives at IIT Bombay

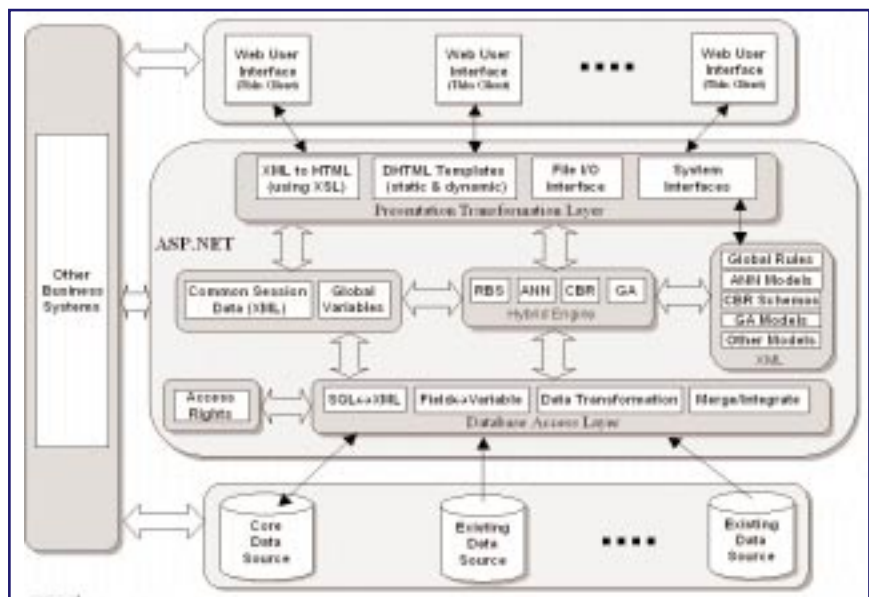
The School of Management has developed a framework (set of

tools) to develop and deploy state-of-the-art intelligent websites and web-based generic, domain-independent, hybrid intelligent systems. This framework is XML-based, server-centric, and can be used with just a simple Internet browser. A problem can be addressed using the combined strengths of the various intelligent systems. All components of the framework: ES, ANN, CBR engine, GA, database interface and even clients (through files) use data represented in XML format for input, output, and storing parameters. These components can exchange data amongst each other through a common XML interface.

### The Integration framework

The framework has a web page generation wizard, which generates various default HTML templates. Appropriate templates are automatically invoked by the system depending upon the Q & A session. Some of these templates can be used to manage the data at the client machine in an off-line mode. The templates contain JavaScript code for addition, modification, on-line validation, navigation, searching, storing and retrieving data on/from client's machine. The system allows use of global variables that intelligent systems use inside web pages (using JavaScript), as well as web-based output reports. This gives the framework the power of using procedural business logic along with knowledge-based systems.

The framework uses a unique and novel way of integrating various intelligent systems and data sources in web environment. Representing the problem as well as result (output) as a *case* in a common XML format makes it flexible to store, interchange, and use the session data across various



The Integration framework

intelligent systems. There are other advantages of using this kind of framework apart from developing hybrid intelligent systems. For example, the rule-based engine can be used to integrate data sources to view data in a uniform way. The Q&A interface on top of database interface provides a self-help kind of environment while seeking information. The School of Management is developing various prototype applications in banking and finance that use the combined strengths of intelligent systems.

Contact: [rm\\_sonar@iitb.ac.in](mailto:rm_sonar@iitb.ac.in)

# Technologies and Strategies for Urban Infrastructure Management

## Transport Infrastructure Projects in Mumbai

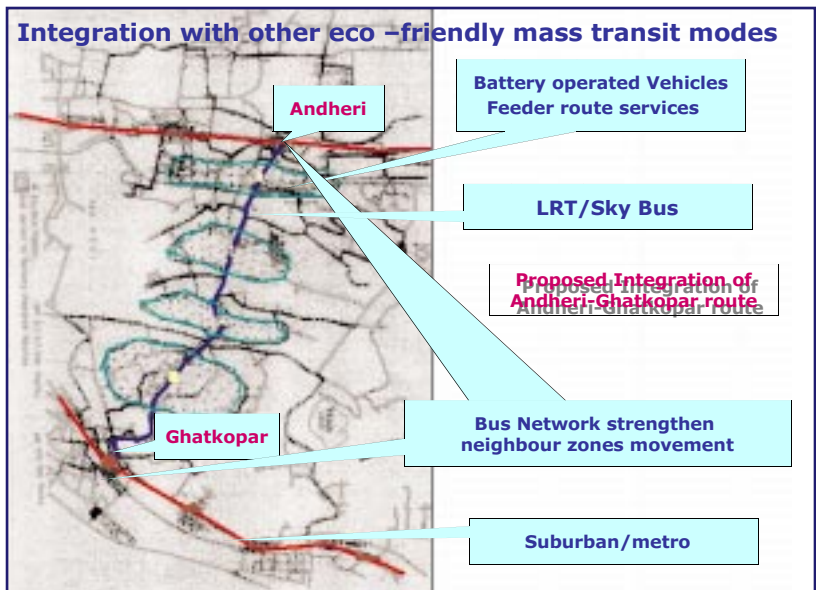
S L Dhingra, Department of Civil Engineering

Transport infrastructure projects are vital to reduce congestion, delay and environmental problems of any metropolitan city. For example, Mumbai's burgeoning population of over 12.6 million severely strains the city's infrastructure with 14 million trips being undertaken in a single day. About 88% of these trips are catered to by the suburban railway and the public bus transport system. Overcrowding has grown to such an extent that 4,500 to 5400 passengers now travel per 9-car train during peak hours, as against the rated carrying capacity of 1,700. This results in a "super dense crush load" of 14-16 standing passengers per square metre of floor space! In addition, the entire fleet of 3380 buses carry 4.5 million passengers daily on 335 routes.

Several developmental measures are being implemented under the World Bank aided MUTP-II. Through the MMRDA, the Government of Maharashtra has embarked upon projects on road improvements and flyovers. It has also been exploring the suitability of various efficient, economical and non-polluting Mass Rapid Transit Systems (MRTS) like the proposed Mumbai Metro. The MRTS are expected to improve East-West connectivity in Mumbai suburbs, and reduce trainloads from the current 3.5 times the desirable density, to 1.5 times in the final phases. The first phase which consists of the Ghatkopar-Andheri-Versova section runs for 11.4 kms with a branch to Sahar International Airport. The alignment is fully elevated and stations have been planned to allow good interchange facilities with other modes of transport such as battery operated vehicles, suburban rail and metro rail, and buses. The map shows the proposed integration of the Andheri-Ghatkopar link. The stations will also have automatic fare collection systems and modern communication facilities. IIT Bombay has been involved in the selection of alignment and fare sensitivity analysis of MSRDC's Elevated Mass Rapid Transit System for Thane city (Ring Railway), as also in the assessment of safety of Light Rail Transit Systems (Skybus). The institute faculty has been on various Technical Advisory Committees to numerous projects from conception to implementation. Expertise is available in Environmental Impact Assessment (EIA) of transport infrastructure projects, evaluation and design of intelligent transport systems, and economic evaluation of projects. The aim is to help various planning agencies such as MMRDA, MSRDC, CIDCO, BEST etc to plan an integrated, multimodal, eco-friendly urban mass transport infrastructure for sustainable urban development.

In about 4 years, Mumbai city stands poised for a landmark structure through the Bandra-Worli Sealink Project. The aim of this MSRDC project is to link Bandra and Worli through two single pylon cable-stayed, 8-lane bridge. The present 5.2 km stretch has 22 junctions and involves a travel time of 40-60 mins. The bypass toll bridge would bring down

the travel time to 6 mins. The toll plaza will house control facilities for electronic tolling, CCTV, traffic counting and classifying variable message signs, remote weather information station, emergency telephones, and surveillance and control for incidence management. The intelligent bridge system will provide for 3 modes of toll collection including manual, semi-automated (through Smart Card) and fully automated systems (through toll tags and transponders to allow a non-stop passage). IIT Bombay has been involved in the feasibility



study of this project, and travel demand forecasting by using Stated Preference Survey techniques. The Institute has been involved in the EIA of the Haji Ali-Wilson College Viaduct and the Western Freeway Sealink Project which, apart from travel impact, comprises ecological, social and economic impacts associated with such projects. IIT Bombay has also offered expertise to the demand forecasting of the latter project which will connect Haji Ali to Nariman Point and Cuffe Parade, the Trans-harbour link etc.

The Institute has been closely associated with the impact studies of 42 projects under MUTP-II, including design of dispersal systems, parking places, and exits in the event of disasters. The studies involved the development of a methodology for EIA, which has been published as a chapter in 'The Handbook of Transport and the Environment' (Elsevier Publications, 2003) In some recently concluded projects, IIT Bombay has also helped the Airport Authority of India in the evaluation of runway pavement design with modified bitumen, analysis of runway pavement unevenness, and traffic circulation plan and multistoreyed parking for Mumbai Airport. The Institute is a member of the Executive Committee of NRRDA for implementing and overseeing Pradhan Mantri Gram Sadak Yojana (PMGSY) projects in the country. It is also the Principal Technical Agency covering 17 districts in Maharashtra State, its activities including training of engineers.

Contact: [dhingra@iitb.ac.in](mailto:dhingra@iitb.ac.in)

## Disaster Management: Earthquakes

Ravi Sinha, Department of Civil Engineering

India is highly vulnerable to earthquakes, with more than 60% of the land being prone to shaking of intensity VII and greater, which may result in structural damage. Several damaging earthquakes have occurred in recent past including: Bihar-Nepal (1988), Uttarkashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999) and Bhuj (2001). These recent earthquakes have resulted in the death of nearly 25,000 people. Most deaths are caused due to collapse of man-made structures and many recent earthquakes have indicated the under-preparedness of the country to face its impacts. Since it is as yet difficult to make short- or mid-term predictions, seismic safety of built environment that will ensure that structures do not collapse, forms an important cornerstone of earthquake disaster mitigation efforts.

During the last 15 years, IIT Bombay has taken up extensive research, development and outreach activities in the area of earthquake engineering. The institute has several faculty members who collectively, cover all major areas in earthquake engineering including: Structural Earthquake Engineering, Geotechnical Earthquake Engineering, and Seismology/Geology. The state-of-the-art research and development activities are recognized both nationally and internationally. The institute has filed two patent applications based on this research. IIT Bombay played a proactive role in pro-



viding technology support and expert advice for reconstruction and disaster mitigation following the devastating earthquake in Gujarat in January 2001. The advice was provided to Government of Gujarat as well as several multilateral agencies such as the World Bank and Asian Development Bank.

The outreach activities include:

- ▶ Development of National Codes and Standards with Bureau of Indian Standards
- ▶ Assistance to the government in developing policies and regulations considering earthquake engineering knowledge
- ▶ Intensive professional and continuing education programs for college teachers and the industry
- ▶ Core participation in National Program on Earthquake Engineering Education (NPEEE), launched by the Ministry of Human Resources Development.
- ▶ Training of government officers and UN volunteers to carry out rapid seismic vulnerability assessment buildings in 38 earthquake-prone cities of India
- ▶ International collaborations with China, Bangladesh, Nepal, and Uzbekistan in urban risk management efforts
- ▶ Active collaboration in earthquake engineering with several German universities and Institutes

Contact: [rsinha@civil.iitb.ac.in](mailto:rsinha@civil.iitb.ac.in)

## Mitigating Urban Flooding

Kapil Gupta, Department of Civil Engineering

Recurring flooding during the monsoons is the bane of the civic life of several Indian cities. At present, about 285 million people live in 35 metro cities. These figures are projected to increase to 618 million in 70 metro cities by the year 2021. Apart from seriously impeding free movement of people and transport, and posing threats to life and property, flooding also leads to outbreak of epidemics thereby causing loss to business and industry.

Current research at IIT Bombay addresses two major aspects of urban flood control through analytical work and laboratory studies related to overflows. This involves a study of the Kalyan catchment area and the Mithi River catchment area of Mumbai. In the event of non-feasibility of structural remedies for storm drains, non-structural methods like controlling flows at key points in the drainage system by systematic operation of gates located at suitable points in the drainage system are being explored. The work involves online monitoring of rainfall data, and formulating real-time control algorithms to maintain flow at pre-



determined levels. Once these algorithms are in place, the technology will be transferred to the local municipality for implementation. In future, similar systems can also be replicated in other cities like Kolkata, Bangalore and Hyderabad, which also face similar problems.

*Overflows* occur due to accumulation of large amounts of solid waste in storm drains, and result in the introduction of pollutants into slum areas. The challenge is to minimize overflows by trapping the 'settleable' solid waste through the provision of sediment traps at appropriate locations in the drainage system. Present work at IIT Bombay is focused on achieving optimal configurations of sediment traps using

Computational Fluid Dynamics software. It is envisaged that overflows may be minimized through entrapment of sediment at predetermined locations and its subsequent disposal. Such measures will thereby help in mitigating impacts of disasters caused due to urban flooding in overpopulated urban areas.

Contact: [kgupta@civil.iitb.ac.in](mailto:kgupta@civil.iitb.ac.in)