

Annual Report

2005-2006



Indian Statistical Institute

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AS ON MARCH 31, 2006

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12. Dr. Pradyumn Sen, Advisor, Perspective Planning Division, Planning Commission, New Delhi

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13. P. J. M. G. Nadkarni, Dept. of Mathematics, Mumbai University, Mumbai

Scientists employed by the Institute

14. Prof. Sanku Basu, Vice-Chancellor, Vasa Bharati University, Santiniketan
15. Prof. Banu De, former Director, Centre for Studies in Social Sciences, Kolkata

Elected representatives of members of the Institute

16. Prof. Deb Kumar Bose, Kolkata
17. Prof. Shyam Maiti, New Delhi

Elected representatives of the employees of the Institute

18. Dr. Sandip Mitra, Representative of the Scientific Workers
19. Shri Probst Chatterjee, Representative of the Non-Scientific Workers

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20. Prof. Asit Baran Raha, Professor-in-Charge, Theoretical Statistics and Mathematics Division
21. Prof. Tapas Samanta, Professor-in-Charge, Applied Statistics Division
22. Prof. Amrita Majumdar, Professor-in-Charge, Social Sciences Division
23. Prof. Himadri Pal Marudat, Professor-in-Charge, Physics and Earth Sciences Division
24. Dr. Joydev Chattopadhyay, Professor-in-Charge, Biological Sciences Division
25. Prof. Malay Kumar Kundu, Professor-in-Charge, Computer and Communication Sciences Division
26. S. P. Bhattacharyya, Head, Statistical Quality Control and Operations Research Division
27. Prof. K. L. Karandikar, Head, Delhi Centre
28. Prof. J. K. Raychaudhuri, Head, Bangalore Centre
29. Dr. Sujit Kumar Majumdar, Dean of Studies

Non-Member Secretary

Shri Dilip Chandra Pal, Chief Executive (Administration & Finance)

INDIAN STATISTICAL INSTITUTE

Indian Statistical Institute
Kolkata 700 108



Annual Report April 2005 – March 2006



203 Barrackpore Trunk Road
Kolkata – 700 108
(<http://www.isical.ac.in>)

INDIAN STATISTICAL INSTITUTE
SEVENTY FOURTH ANNUAL REPORT
April 2005 - March 2006

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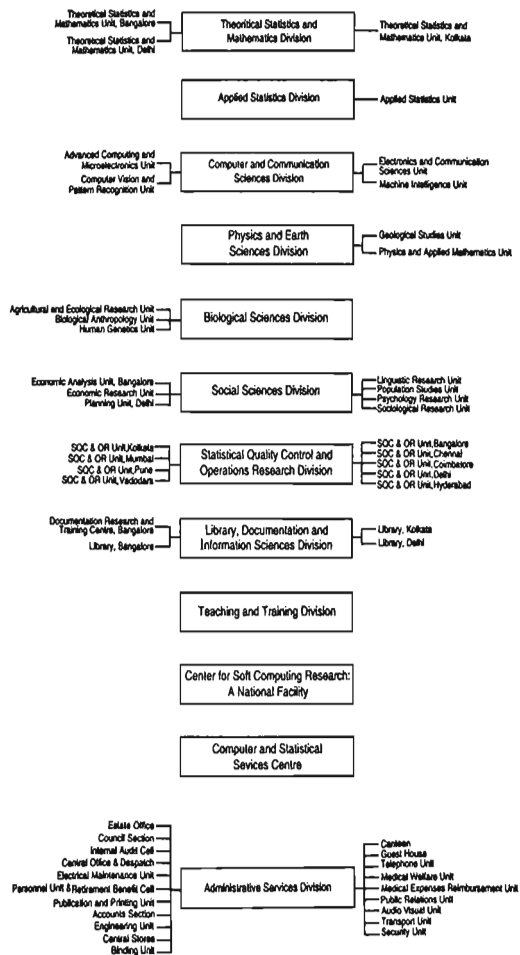
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Organization of ISI by Divisions and Constituent Units



Director's Report

It is my proud privilege and pleasure to present my annual report for the year 2005-06, which happens to be the first one after I assumed the post of the Director of the Institute on August 1, 2005. The Institute has its headquarters in Kolkata and two other centers at Delhi and Bangalore beside a branch at Girdih and a network of service units under Statistical Quality Control and Operations Research Division across the major cities in the country like Kolkata, Delhi, Bangalore, Mumbai, Chennai, Hyderabad, Pune, Vadodara and Coimbatore.

True to the tradition of the Institute, a number of prestigious awards and honors have been received by some of our scientists during the year, for significant contributions in their respective fields. I mention a few of them: Professor Probal Chaudhuri of the Theoretical Statistics and Mathematics Unit of Kolkata received the 2005 Shanti Swarup Bhatnagar Prize in Mathematical Sciences from the Council of Scientific & Industrial Research, and the National Award in Statistics for Young Statisticians in Honour of C.R. Rao by the Ministry of Statistics & Programme Implementation, Government of India. He had also been elected a Fellow of the Institute of Mathematical Statistics (USA). Professor Rajeev Karandikar of the Statistics and Mathematics Unit of Delhi had been elected a Fellow of the Indian National Science Academy (FNA) while Professor Arup Bose of the Theoretical Statistics and Mathematics Unit of Kolkata had been elected a Fellow of the Indian Academy of Sciences (FASc). Professor Malay K. Kundu of Machine Intelligence Unit had been elected a Fellow of the Indian National Academy of Engineering (FNAE), and Professor B.B. Chaudhuri of the Computer Vision & Pattern Recognition Unit received the R.K. Wadhwa Gold Medal from the Institute of Electronics and Telecommunication Engineers, India. Among the young researchers, Dr. Partha Sarathi Chakraborty of the Statistics and Mathematics Unit of Delhi was awarded the Young Scientists Medal by the Indian National Science Academy. The Institute is proud of their achievements.

I am also pleased to mention that the DST-sponsored first ever "Center for Soft Computing Research: A National Facility" was inaugurated by Professor MGK Menon, the President of the Institute, on October 25, 2005, and it has started functioning, forging several collaborations with other institutes in India. Its activity, as entrusted by the DST under intensification of research in High Priority Areas (IRPHA), will not only strengthen the ongoing computer science research in the Institute, but will also add a new dimension to it, demonstrating its significance and timeliness in the national IT scenario.

The Institute has a long and glorious tradition of fundamental research in several areas that was being carried on during the year with vigour by its distinguished faculty members. It also continued to conduct, again with the help of its able faculty members, prestigious courses, and to produce successive generations of students well-trained for research and other professions. The courses were updated from time to time to cater to the needs of the students. A new specialization in the M.Stat. program, called M.Stat. : Applications, will be introduced from this year to enrich the program. This will widen the opportunities available to the graduating students in industry and other job markets, as well as for pursuing higher studies.

There were about 100 externally (both national and international, Government and Private) funded projects in the Institute. Funding agencies mainly include the DST, DBT, CSIR, DIT, ISRO, DRDO, DAE, ICMR, Ministry of Environment and Forests, Intel Corporation (USA), NSF (USA), INSEAD (France), Indo-French Center for Promotion of Advanced Research, NHF (Netherlands), Hewlett Packard e-global, Iran Khodro Company (Iran), L&T, Macmillan, WIPRO, and Reliance. Many of the projects had strong research components. Apart from these there were projects of SQC & OR Division which were mostly of a consulting and income-generating nature. While the number of small projects is going up yearly, emphasis should be given, in my opinion, to having some big interdisciplinary projects of national importance, which cut across the different divisions of the Institute and exploit their respective expertise. This is particularly appropriate in view of the fact that the Institute has a unique multi-disciplinary character that is aptly described by its motto of "Unity in Diversity". Similarly, more inter-institutional projects were encouraged with the same synergistic objective where scientists should have deeper involvement in fewer projects rather than shallow involvement in several. Also, requests from Government to conduct projects of national significance in areas related to planning, finance, etc.,

Director's Report

should be entertained wherever possible, and efforts could be made to embed research components in such activities.

The construction work for the Phase II of the academic building, now renamed by the Ministry as "Platinum Jubilee Academic Building", and the D type quarters in Deluxe Garden has begun. Major renovation work is going on in full swing in the RTS building and the ISEC Hostel. The objectives are to enhance the longevity of the former, which embodies our proud heritage from the illustrious founder of the Institute, and to upgrade the facilities for international students in the latter. An ATM counter of the Allahabad Bank has been opened for the benefit of the workers and students.

The current pay scales in the Institute, given the entry-level qualification requirements, do not compare favorably with those at other premier Indian Institutes. As a result, the Institute has not been able to attract good faculty in sufficient number in recent years. To deal with this, attempts are being made to revise the existing pay scales and promotional policies for the faculty in order to attract bright young researchers at an early stage of their career. Also, efforts are being made at the advice of the Section 8(1) Committee to revive the Institute's campus at Takdah, Darjeeling, with a possibility of its scientific utilization, in conjunction with other research centers around, through sharing of resources and infrastructure in the greater interest of the nation.

I am pleased to announce that the Institute will be celebrating its Platinum Jubilee over a period of about one year, starting from December 17, 2006. Though the preparatory work started quite late, we hope to have about fifty academic programs like conferences, workshops, seminars, lecture series, quiz, and infrastructural development in all the major centers with sincere cooperation from the workers. The latter activity mainly includes a separate integrated ISEC Center in the North Cottage of the Institute in Kolkata and a subway to connect it to the academic area, a Boy's Hostel in its Delhi Center and an Auditorium in the Bangalore Center.

Indian Statistical Institute is internationally recognized as a "Centre of excellence" both for its theoretical contributions to Statistics as well as applications of Statistics. We must uphold this unique standard in years to come in order to keep the banner of the recognition high, cherishing our immortal mottoes, "Work is worship" and "Unity in diversity". We hope to have continued assistance and cooperation from our administrative ministry for smooth running of the Institute and also to add more feathers to its cap.

31st March, 2008

Sankar K. Pal

A BRIEF HISTORY OF THE INSTITUTE

In the nineteen twenties, P.C. Mahalanobis, then a Professor at Presidency College, Calcutta conducted several studies employing statistical methods with results that vindicated his ideas about the efficacy and potential of the emerging science of Statistics. In 1931 he founded the Indian Statistical Institute, as a registered non-government and non-profit distributing learned society under the Societies Registration Act No. XXI of 1860. It has the following objects:

- (i) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to problems of planning for national development and social welfare;
- (ii) to undertake research in various fields of natural and social sciences with a view to the mutual development of statistics and these sciences;
- (iii) to provide for, and undertake, the collection of information, investigations, projects, and operational research for purposes of planning and the improvement of efficiency of management and production.
- (iv) To undertake any other ancillary activities in fulfillment of the objectives (i), (ii) and (iii)

The Institute started functioning, initially from a room of the Presidency College, with some support from a few distinguished citizens of Kolkata. Over the first two decades, in what has now become a glorious chapter in the history of Indian science and institution building, the Institute embarked on a series of ambitious and visionary programmes, mainly in the form of large-scale sample surveys which extended into other innovations and methodological research that have since become classics in Statistics. Side-by-side grew the activities of training of personnel, which were also to trigger high level research, and the need for publication of results for which Sankhya, an international Statistics journal was founded in 1933.

Apart from the impact made in the world of Statistics, earning for the Institute the patronage of the great R. A. Fisher, the brilliant choice of the area of surveys, their social and national relevance earned the Institute an automatic place in the task of nation-building when India became independent. Led by Professor Mahalanobis and a very able group of younger statisticians including R.C. Bose and C. R. Rao the Institute was poised to take on the larger role. The nineteen fifties saw the Institute engaged in : (i) a full fledged research and training school in Statistics and Probability, (ii) a planning wing entrusted with the formulation of the second five-year plan of India, (iii) Sankhya, (iv) the National Sample Survey wing engaging in comprehensive data collection for the nation, (v) a string of Statistical Quality Control units promoting the quality movement at the industrial centres in the country, and (vi) a collaboration with the International Statistical Institute to train Government statisticians from Asia and Africa, to name some of the principal activities. It was also at this time that the Institute installed the first electronic computer in the country. The faculty, the students and the very distinguished lot of international academic visitors made it a vibrant centre of research and learning.

The formal recognition came in 1959 with the Parliament passing the ISI bill, leading to the Indian Statistical Institute Act of 1959, which designated ISI as an Institute of national importance. The activities steadily grew, existing interests became more broad-based and a number of science units were created in the interest of live interaction between Statistics and Natural and Social Sciences. Empowered by the Act to award degrees, the Institute started the B.Stat. and M.Stat. courses. An excellent library was founded at Kolkata and the Documentation Research and Training Centre began functioning in Bangalore. Other Infrastructure development also began.

In the nineteen seventies, after the death of Professor Mahalanobis, the Institute went through some reorganisation. The National Sample Survey had already been taken out of the Institute. The various units and activities were grouped under a few divisions. The present structure of ten divisions on page (iv) has been arrived at through some further changes. The diversity in areas of research in the Institute has grown manifold in comparison with the nineteen seventies. The most notable changes

Brief History

since then have been the emphasis on Computer Science and the creation of the two centres at Delhi and Bangalore with full-fledged research and teaching programmes. The Indian Statistical Institute Act of 1959 was amended by the Parliament in 1995 to empower the Institute to award Degrees/Diplomas not only in Statistics, but also in Mathematics, Quantitative Economics, Computer Science and such other subjects related to Statistics as may be determined by the Institute from time to time. Several new courses have also been added since: M. Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, M.S. in Quantitative Economics, B. Math. and M. Math.

The Institute in its seventy fourth year is proud of its past and present, of the high level of research and applications, of the distinguished alumni spread over many countries. Comprehensive planning has been on to observe the platinum jubilee of the Institute in 2006-07 in a fitting manner, with international conferences, seminars, and lecture series in all relevant disciplines. Plans have also been made to bolster the infrastructure of the Institute. Above all, the occasion will be used to renew the pledge of excellence!

**Part I. Teaching & Training,
Research & Other Scientific Activities, and Publications**

Teaching and Training

The Sunity Kumar Pal Gold Medal for the best dissertation in M.Tech. (CS) was given to :

Saurav Basu

The S. H. Aravind Gold Medal for outstanding performance in B. Math. (Hons.) was given to :

Suchanti Sarkar.

Table – 1

Number of students/fellows in different courses.

Sl. No.	Courses	Number of Students		
		Passed In the Annual Exam. In 2005	During the year 2005-06	
01.	B.Stat.(Hons.)	1 st year	28	35
		2 nd year	29	28
		3 rd year	17	33
02.	B.Math.(Hons.)	1 st year	12	10
		2 nd year	9	12
		3 rd year	13	9
03.	M.Meth.	1 st year	2	9
		2 nd year	6	2
04.	M.Stat.	1 st year	40*(23+17)	16*(11+5)
		2 nd year	36*(32+4)	40*(36+4)
05.	M.S.(QE)	1 st year	19	19
		2 nd year	20	17
06.	M.Tech. (CS)	1 st year	17	21
		2 nd year	22	17
07.	M.Tech.(QROR)	1 st year	10	11
		2 nd year	13	10
08.	Junior & Senior Research fellows & Research Associates in different disciplines		9	85
09.	ADIS	1 st year	4	9
		2 nd year	5	4
Grand Total			311	387

* Total number, including Kolkata and Delhi.

Numbers in bold stand for those receiving their degree at the 40th annual convocation.

Table 2

Ph.D. Degree awarded by the Institute in the 40th Convocation held on 17.2.06

Sl. No.	Name of the Fellow	Title of the Thesis	University/ Institute	Name of the Supervisor(s)
1.	Debrup Chakraborty, M. Tech. (CS), (ISI)	Building Efficient Systems From Data in Computational Intelligence Framework.	ISI	Prof. N.R. Pal, ECSU, ISI., Kolkata
2.	Utpal Garain, Master of Comp. Sc. and Engg. (Jadavpur Univ.)	Automatic Recognition of Printed and Handwritten Mathematical Expressions.	ISI	Prof. B.B. Chaudhuri, CVPRU, ISI., Kolkata

Teaching and Training

3.	Paramita Das, M. Stat. (ISI)	Structure of Relative Commutants of Depth Two Subfactors.	ISI	Prof.V. Kodyialam, Inst. of Math. Sciences, Chennai
4.	Ramakumar Ramasubramonian, M. Sc. (Agricultural Economics), (Tamil Nadu Agricultural University)	Socio-Economic Characteristics of Agricultural Workers: A Case Study of a Village in the Malabar Region of Kerala.	ISI	Prof.V.K.Ramachandran S.R.U., ISI, Kolkata
5.	Lingeraj Sahu, M. Phil. (Maths) (Sambalpur Univ.)	Quantum Stochastic Dilation of a Class of Quantum Dynamical Semigroups and Quantum Random Walks.	ISI	Prof. K.B. Sinha, Stat-Math Unit, ISI, Delhi Centre
6.	Sonali Roy, M. S. (OE), (ISI)	Essays on Individual and Collective Powers in a Voting Body.	ISI	Prof. S.R. Chakravarty, ERU, ISI, Kolkata
7.	Sanjay Parui, M.Sc. (Maths.), (University of Calcutta)	Uncertainty Principles on Nilpotent Lie Groups.	ISI	Prof. S. Thangavelu, Stat-Math Unit, ISI, Bangalore
8.	Arup Kumar Das, B.E. in Metallurgy, (University of Calcutta) P.G. Diploma in SQC & OR (ISI)	Properties of Some Matrix Classes in Linear Complementarity Theory.	ISI	Dr. S.K. Neogy, SQC & OR Unit, ISI, Delhi Centre
9.	Mridul Nandi, M. Stat. (ISI)	Design of Iteration of Hash Functions and its Cryptanalysis	ISI	Prof. B.K. Roy, ASU, ISI, Kolkata

Table 3

Research Fellows of ISI who have been awarded Ph.D. degree by Academic Bodies other than ISI during 2005 for work done in the ISI.

Sl. No.	Name of the Fellow	Title of the Thesis	University	Name of the Supervisor
1.	Paramita Shattacharya	Host Factors that may Influence Cervical Cancer with High Risk Human Papillomavirus Infection: Aspects of Molecular Mechanism of the Disease.	Jadavpur University	Dr. S. Sengupta, HGU, ISI.
2.	Rachana Chattopadhyay	Entrepreneurial Behaviour: A Socio Psychological Approach for Predicting Entrepreneurial Success.	University of Calcutta	Dr. A. Ghosh PRU, ISI
3.	Gautam Mukhopadhyay	The Potential of Aquatic Plants as Bioindicators of Pond Water Quality.	University of Calcutta	Dr. A. Dewanji, AERU, ISI.
4.	Rajib Kumar Mitra	Physicochemical Studies on Some Single and Mixed Microemulsions/Reverse Micellar Systems.	Jadavpur University	Dr. B.K. Paul, GSU, ISI.

Teaching and Training

5.	Rupanwita Gayen Chowdhury	Water Wave Scattering by Obstacles and Surface Discontinuities.	University of Calcutta	Prof. B. N. Mandal, PAMU, ISI.
6.	Koelli Ghoshal	On Velocity and Suspension Concentration in a Rediment-laden Flow: Experimental and Theoretical Studies.	Jadavpur University	Prof. B. S.Mazumder, PAMU, ISI.
7.	Rana Saha	An Investigation on Secular Changes and Socio-economic Factors in Physical Growth, Maturation and Nutritional Status of the "Bengalee Boys of Calcutta".	University of Calcutta	Dr. P. Dasgupta, BAU, ISI.
8.	Arupendra Mozumder	Health of Urban Disabled : A Bio-social Study in Calcutta and Suburbs	University of Calcutta	Dr. Subrata K. Roy BAU, ISI.

Short-term training

Apart from the regular courses, in 2005 - 2006, 236 trainees of Engineering and Technology courses from various Universities/Institutions were imparted training of varying duration (two weeks to three months) under supervision of faculty at the following units of the Institute: ACMU, Agri. & Eco. Res. Unit, ASU, Bio. Sc. Divn., CSSC, CVPRU, Dean's Office, ECSU, MIU, SQC & OR. A list of the Universities/Institutions is given in the next paragraph.

B.P. Poddar Institute of Management & Technology, Dr. B. C. Roy Engineering College-Durgapur, Electronics Corporation of India Limited - Kolkata, Futura Institute of Engineering and Management - Kolkata, Banasthali Bidyapith - Rajasthan, Bankura Unnayani Institute of Engineering, Bengal Engineering and Science University, Birbhum Institute of Engineering & Technology, Birla Institute of Technology - Mersa, Capital College - Bangalore, College of Engineering & Management - Kolaghat, Indian Institute of Information Technology - Allahabad, MCKV Institute of Engineering, University College of Engineering - Buria, Government College of Engineering & Leather Technology, Heritage Institute of Technology, IGNOU - Kolkata, IGNOU - Delhi, Indian School of Mines - Dhanbad, Institute of Engineering & Management - Salt Lake, Jadavpur University, JIS College of Engineering - Kalyani, Kalyani Government Engineering College, M. B. Khalsa College - Indore, Mallabhum Institute of Technology - Bankura, Manipal IT Education - Sikkim Manipal University, Meghnad Saha Institute of Technology, Narula Institute of Technology, National Institute of Technology - Durgapur, Netaji Subhas Engineering College- Kolkata, North Orissa School of Communication & Management Studies, Orissa Engineering College, Pailan College of Management & Technology, RCC Institute of Information Technology - Beliaghata, Saroj Mohan Institute of Technology, Sikkim-Manipal Institute of Technology, Siliguri Institute of Technology, Sri Jayachamarajendra College of Engineering - Mysore, Techno India, The ICFAI School for Information Technology - Hyderabad, The Institute of Computer Engineers (India), University Institute of Technology - University of Burdwan, University of Burdwan, University of Kalyani, University of North Bengal, Vellore Institute of Technology - Vellore, Tamilnadu, Vidyasagar University - Midnapore, W. B. University of Technology - Salt Lake, Centre for IT Education (Orissa), Madhav Institute of Technology & Science (Gwalior), Sathyabama Institute of Sc. & Technology (Chennai), Uttal University (Bhubaneswar), Visva-Bharati (Santiniketan), IIT-Khragpur, Indian Institute of Software Technology).

2. INTERNATIONAL STATISTICAL EDUCATION CENTRE (ISEC)

Established in 1950, and operated jointly by the International Statistical Institute, Netherlands and the ISI under the auspices of the Government of India, the centre functions under a joint Board of Directors. Professor C.R. Rao, FRS has been the Chairman of the Board since 1972. The centre

Teaching and Training

provides training in theoretical and applied Statistics at various levels to selected participants from countries in the Middle-East, South and South-East Asia, and the Commonwealth countries in Africa. The programmes are: a ten-month regular course leading to Statistical Training Diploma, and special courses of varying duration. The regular part has a six-week module organized by the Ministry of Statistics and taught at Delhi by Statistical Officers of the Government of India.

The 59th term regular course was held during the 2005-06 session with 19 participants, of whom 10 were supported by the Govt. of India under TCS of Colombo Plan, 7 by the India Technical and Economic Cooperation, and one by the Central Bank Of Sri Lanka. The candidates came from Indonesia, Thailand, Sri Lanka, Tonga, Gambia, Ivory Coast, Myanmar and Bangladesh and all the 19 candidates successfully completed the course. Of special courses there were two during 2005-2006, each of one-month duration organized for three students from Gambia. Professor S.K.Pal, the Director of the Institute presided over the ISEC convocation held on 22 march 2006, in which Professor D.Dutta Majumder, Professor Emeritus at the Institute was the chief guest and gave the convocation address.

Thanks to the special interest shown by Professor Pal, Director, ISI there has been great improvement in the infrastructure for the ISEC during the last year and more ambitious projects in this direction have been drawn up.

2. RESEARCH AND OTHER ACTIVITIES

The major thrust of the Institute is on research in various disciplines comprising Theoretical and Applied Statistics, Mathematics, Computer Sciences, Biological Sciences, Economics and other Social Sciences, Physics and Earth Sciences, Statistical Quality Control and Operations Research, and Library and Information Sciences. Scientists of the Institute carry out independent research in their own basic discipline and also undertake interdisciplinary research in collaboration with other units within the Institute and also with outside organizations. The Institute also takes up various internally and externally funded projects in diverse fields on challenging live problems of national and international importance. As a part of research activities, scientists of the Institute are involved in consultancy work as well. This section gives a brief account of the principal areas of work over the past year of the scientific divisions of the Institute, namely, the Divisions of :

Theoretical Statistics and Mathematics

Applied Statistics

Computer and Communication Sciences

Physics and Earth Sciences

Biological Sciences

Social Sciences

Statistical Quality Control and Operations Research

Library, Documentation and Information Sciences

In addition, there is a report each from the 'Center for Soft Computing Research: A National Facility' and the 'Computer and Statistical Services Centre'.

Theoretical Statistics and Mathematics Division

The Division with a unit each in Kolkata, Delhi and Bangalore is engaged in research in Statistics, Probability Theory and Mathematics, with a small group in Kolkata pursuing Theoretical Computer Science. Beside their research, members play a major role in the teaching of Statistics, probability, Mathematics and Theoretical Computer Science in the B.Stat.(Hons.), B.Math.(Hons.), M.Stat. and M.Tech. (Computer Science) programmes of the Institute. Courses are also run for research fellows and there are seminar activities all round the year. Members organized and taught in several specialized workshops, some of them under the North-east programme. The administration of Sankhya is also done from this division and a number of faculty members are also engaged in its editorial functions. Some of the faculties are also associated with the administration of the Mathematics Olympiad Project of the NBHM at the regional and national levels.

Stat-Math Unit, Kolkata

Records and maxima of random variables

Major progress was made in understanding the maxima of multinomially distributed exchangeable random vectors, where dimension increases with n , cell probabilities are equal and number of trials increases fast enough. This work is being jointly done with Anup Bose and Amites Dasgupta of SMU Kolkata.

Krishanu Maulik

Commutative algebra

Some results have been obtained on finite generation of subalgebras of polynomial algebras and on the structure of codimension-one A^1 -fibrations in collaboration with N. Onoda of Fukui University, Japan

A. K. Dutta

Applications of graph theory to chemistry

Results were obtained regarding: Energy of molecules and Graphs and signed graphs, Determination of the set of Energy numbers of graphs on p vertices with a given property Q , Existence of a large number of non-isomorphic graphs with the same energy numbers.

S. B. Rao

Partial sums of upper records

Consider the continuous time process generated by interpolation of the sequence of partial sums of upper records. Under an appropriate condition, It was shown this process converges to a Gaussian process. As a consequence the partial sum of upper records has a limiting normal distribution.

Anup Bose, Sreela Gangopadhyay and Anish Sarkar (SMU, Delhi)

Tail sum of lower records

A condition under which the tail sum of lower records converges in distribution has been derived. This result is useful in understanding the suitability of the method of generating observations from a given infinitely divisible distribution by using sums of lower records.

Anup Bose, Sreela Gangopadhyay, Krishanu Maulik and Anish Sarkar (SMU, Delhi)

Weighted least squares estimation

A weighted least squares estimation procedure in the classical ARCH model has been proposed and its asymptotic properties derived – in collaboration with Kanchan Mukherjee (University of Liverpool). An appropriate bootstrap procedure to estimate the finite sample distribution is also proposed. This method is asymptotically valid and simulation results for small sample sizes are also extremely encouraging.

Anup Bose

Contiguity and separation of probabilities

In the literature absolute continuity/singularity of two probabilities on the coin-tossing space have been studied where one probability represents independent tosses of a fair coin, while for the other probability, a biased coin is tossed at renewal times of an independent renewal process and a fair coin is tossed at all other times. By allowing possibly different biases at the different renewal times, these results have been extended. The contiguity and asymptotic separation properties in this kind of set-up was also investigated and some sufficient conditions obtained.

Anup Bose, Sreela Gangopadhyay and Alok Goswami

Multicolor Urn

A unified approach to central limit theorems for a class of irreducible urn models with constant replacement matrix has been taken. Depending on the eigenvalue, appropriate linear combinations of the number of balls of different colors was considered. Then under appropriate norming the multivariate distribution of the weak limits of these linear combinations is obtained and independence and dependence issues were investigated.

Gopel K. Basak and Amites Dasgupta

Research Activities

Clinical trials

Adaptive data-dependent allocation designs are used in phase III clinical trials having two or more competing treatments with sequential entrance of patients, in order to allocate a larger number of patients to the better treatment.

The odds ratio is a popular concept for biomedical practitioners and hence odds ratio based adaptive designs could be very useful in practice. Several such designs are available in the literature, e.g. Rosenberger et al. (2001) introduced them very briefly; however, they did not study their theoretical properties. In this research, these designs were described by means of urn models, and rigorous limiting results for them were established. The design was then extended for more than two treatments. Also a real data set was used to illustrate the applicability of the proposed design.

Gopal K. Basak and Alanu Bhowmik (ASU)

Utilisation of auxiliary information in sample surveys

In large scale sample surveys, when the study variable is poorly correlated with the auxiliary information which is used as a size measure for probability proportional to size selection, conventional design unbiased estimators do not perform well. Hence alternative estimators that are biased but more efficient are suggested. A detailed study on the bias is also provided.

T.J. Rao

Isotropic C^2 -immersions of a manifold

Existence of isotropic C^2 immersions of a manifold M in a pseudo-Riemannian manifold (E, h) has been studied following the Convex Integration techniques of Gromov. The main result states that if the signature of h is (p, q) such that $p = \dim M$ and $q \geq \dim M$, then there is an isotropic C^1 immersion of M in (E, h) under certain conditions.

Mahuya Datta

Noncommutative geometry of quantum groups

The twisted formulation of noncommutative geometry has been studied in details, and for the noncommutative manifold $SU_q(2)$ (with the geometry coming from a canonical equivariant spectral triple), the twisted and conventional formulations of noncommutative geometry were compared. It is concluded that in this case at least, the two formulations give similar results; in particular the twisted Chern character is also nontrivial like the usual Chern character.

Debashish Goswami

Operator algebras and quantum groups

Implications of ergodic actions of compact quantum groups on C^* algebras are investigated, using the results of Boca and Landstad which describe the structure of algebras which admit such actions. In particular, an interesting description of the crossed product under such actions is obtained.

Debashish Goswami

Quantum Information theory

Some useful complete invariants for local unitary equivalence of mixed bi-partite quantum states are obtained in collaboration with S. M. Fel (IAM, Univ. Bonn) and S. Albeverio (IAM, Univ. Bonn).

Debashish Goswami

Hilbert modules and group action

Let G be a compact Lie group acting ergodically on a C^* algebra A . It is proved that the hypothesis of being countably generated in the results of Mingo and Philips about equivariant imbedding of a countably generated G - A module can be relaxed in this case.

Debashish Goswami

Noncommutative probability

In continuation of our earlier works, some more interesting results about existence of Evans-Hudson dilation of quantum dynamical semigroups with unbounded generators have been obtained.

Debashish Goswami and K B Sinha (SMU, Delhi)

Simple voting games

Characterizations of Coleman indices for voting power have been obtained. The independence of the axioms characterizing the Coleman index was also shown.

Rana Barua and Satya R. Chakravarty (ERU)

Hidden periodicities in DNA sequences

A statistical method for detecting hidden periodicities in DNA sequences has been developed. The method has turned out to be very useful in discriminating between genes and non-coding stretches in a genome.

A statistical technique for identifying genomic islands in bacterial genomes has been developed and successfully implemented in several bacterial genomes.

Probal Chaudhuri

Harmonic analysis

The questions of extending the domain of Radon transform, its mapping properties and its connection with the geometric Fourier transform on the Riemannian symmetric spaces were taken up. The study also extended to these aspects of harmonic analysis on the nonsymmetric harmonic spaces, popularly known as NA groups. Both in the symmetric spaces and on the nonsymmetric spaces the Radon Transform was used as a device to obtain results like Riemann-Lebesgue lemma for L^p functions and For some important theorem of the genre of Uncertainty Principles.

Rudrapada Sarkar

*Stat-Math Unit, Delhi***Martingale problems**

Work was continued on various aspects of martingale problems and their use in characterisation of Markov processes and, further, in linear and nonlinear filtering theory driven by Gaussian noise.

A. G. Bhatt

Optimal designs

A popular measure to assess supersaturated designs is the $E(s^2)$ criterion. Improved lower bounds on $E(s^2)$ have been obtained. $E(s^2)$ -optimal designs attaining the improved bounds have been identified. Two simple but powerful methods of constructing $E(s^2)$ -optimal designs have been obtained.

The problem of allocating factors to the columns of the orthogonal array is studied, so that the user-specified 2-factor interactions, in addition to the mean and the main effects, are optimally estimable. This problem has been investigated with reference to the orthogonal array array OA $(2^n, 2^{n-1}, 2, 2)$, which exists for every integer n greater than 1. A method for the allocation of factors to factor representations has been proposed that ensures the optimal estimation of the mean, all main effects and specified 2-factor interactions.

Ashish Das

Research was carried out in fractional factorial designs, particularly on $E(s^2)$ -optimal supersaturated designs and optimality aspects of designs in the presence of covariates. Quite counter-intuitively, it has been shown that under a one-way model with covariates, a non- design is often better than the best equal-replicate design under the D-criterion.

Aloke Dey

Research Activities

Stochastic dominance under competing risks

In the competing risks model with two risks the data consists of the failure time and the causes of failure; it is of interest to test whether one sub-distribution function (or sub-survival function) dominates the other. However, in many practical situations all the causes of failure are not reported. We develop tests based on U-statistics for such testing problems. The tests have limiting normal distribution. Simulation studies show that the power is high even when 20 to 30 percent of the failure causes are missing.

I. Dewan

Distributions and dependence orderings

New dependence orderings were developed to compare the degree of dependence among bivariate distributions and used to compare pairs of order statistics and record values, and continued work in the general area of stochastic orders and reliability theory.

S. Kocher

Martingale problems and Markov process

Work was continued on interplay between martingale problems and Markov process; Markov chain Monte Carlo technique and other random sampling algorithms were investigated.

R.L. Karandikar

Operator theory

Non-triviality of certain Dirac operators for $SU_q(k+1)$ were investigated, local index formula for odd dimensional spheres derived, and any interesting connection with q -functions, like in the case of $SU_q(2)$ was sought. A decomposition was given of a spectral triple for $SU_q(2)$ constructed by Dabrowski et al in terms of a spectral triple earlier constructed by Partha Sarathi Chakraborty.

A. Pati

Quantum stochastic processes

Results were obtained on problems in quantum information theory, quantum codes and quantum computing.

K. R. Parthasarathy

Research was carried out on quantum stochastic processes, non-commutative geometry and spectral theory of Schrodinger operators.

K. B. Sinha

Parameter estimation

Progress was made with the work on parameter estimation of sinusoidal frequency model and chirp stationary model.

S. Nand

Random graphs and percolation theory

The work concerned a random graph constructed such that edges are only in a given direction. Local properties of this tree are connected with the Dickman equation in number theory and the global properties are connected with random walks on the integer lattice. In particular, for dimensions 4 and above there are the graph contains infinitely many disjoint components, each component being an infinite tree; whereas in dimensions 3 and less the graph consists of a single infinite tree.

Rahul Roy

Work was done on problems of random graphs and percolation theory and also on extreme value theory, in a joint work with N. Konno, N. Masuda and R. Roy, I have studied the threshold network model in which a pair of vertices with random weights are connected by an edge when the summation of the weights exceeds a threshold. We prove some convergence theorems and central limit theorems

on the vertex degree, degree correlation and the number of prescribed subgraphs. Some of these results also generalize to the model with connection are made depending on positions in a spatial model.

A. Sarkar

Stat-Math Unit, Bangalore

Design of experiment

A-optimality of a class of unequally replicated designs with three distinct eigen-values has been proved. A method of construction of these designs has also been given.

For an asymmetrical experiment, an orthogonal main effect plan (OMEPE) is not always economic. An alternative has been considered: "between class orthogonal" main effect plans. The plans constructed require a considerably smaller number of runs than the existing OMEPEs and have many desirable properties of OMEPEs.

Concentrating on OMEPE on non-orthogonal blocking, a new set of sufficient conditions, which can be realised by plans of smaller size, has come up. Examples of such plans are also given.

Optimal crossover designs having substantially fewer units, which remain optimal, have been constructed which would work well in case the experiment has to be terminated halfway due to some unavoidable reason.

Sunanda Bagchi

One parameter semigroups of completely positive maps

One parameter semigroups of completely positive maps are called quantum dynamical semigroups. Work is being done on dilations of contractive quantum dynamical semigroups to semigroups of endomorphisms. For the first time, the dilation for stable quantum dynamical semigroups with bounded generators has been quite explicitly described. The stability here refers to an asymptotic decay property of the semigroup. The International Journal of Quantum Computation has accepted a paper on maximally entangled states for publication.

B. V. Rajarama Bhat

Asymptotic inference in fractionally cointegrated time series models, both linear and nonlinear, with possibly heavy tailed errors.

The following five papers have come out of this study.

1. Convergence in Distribution of Row Sum Processes to Mixtures of Additive Processes.
2. Limit Theorems for Functionals of Sums that Converge to Fractional Stable Motions.
3. Limit Theorems in Network Traffic Models with Very Heavy Tails.
4. Limits of the Number of Level Crossings and Related Functionals of Sums of Linear Processes.
5. Limit laws for the local times of fractional Brownian and stable motions.

P. Jeganathan

Homogeneous operators and Vector bundles

Along with A. Koranyi have obtained a classification of homogeneous operators in the Cowen Douglas class involving infinitely many parameters. Explicit examples of these operators are given on reproducing kernel Hilbert spaces of vector valued holomorphic functions. The reproducing kernel are computed explicitly in the form of a product. The operators are then shown to be irreducible.

Research Activities

Along with I. Bliswas has obtained a classification of homogeneous holomorphic Hermitian vector bundles by prescribing the possible holomorphic structures for such bundles. The equivalence class and irreducibility of these bundles are then determined in terms of this holomorphic structure.

G. Misra

Stochastic differential equations, Martingales

Substantial revisions to the Paper: From finite to Infinite dimensional Stochastic Differential Equations by L.Gawaracki, V.mandrekar and B.Rajeev in which an inequality, obtained in another collaboration with these authors play a crucial role. Both of these are offshoots of a new approach to the study of finite dimensional SDE's proposed in earlier work of B.Rajeev.

The continuation of the work on the Martingale representation theorem with P.Fitzsimmons : This is a study of the properties of the 'Canonical map' which emerged out of the earlier study. It also studies some connections with the results of Yor & Shiryaev (2004).

The work on the Markov properties of last entrance times titled 'Path Transformation of Brownian motion' was submitted to a volume prepared in honour of Professor P.A.Meyer.

In continuation of work with Professor Thangavelu, on the stochastic representations of the Heat equation, more general representations have been obtained. This work also originates in the paper mentioned above.

B. Rajeev

Probability theory In Insurance

A model for a network of insurance companies to diversify risk has been proposed along the following lines. Internal and external borrowing is allowed to avert ruin of any member of the network; this can be looked upon as a reinsurance scheme. This leads naturally to a d-person dynamic game with state space constraints. Under certain natural monotonicity conditions it has been proved that Nash equilibrium is provided by the Skorokhod problem of probability theory. The proposed model is perhaps the first multidimensional model related to actuarial problems.

S. Ramasubramanian

Geometry of Banach spaces

Considerable progress has been made towards solving several problems in Geometry of Banach spaces. A partial solution to the question of algebraic reflexivity of the group of isometries of the space of vector-valued continuous functions on a compact metric space was obtained by showing that for a countable compact set K , for the space of discrete measure-valued functions on K , the isometry group is algebraically reflexive. The structure of the algebraic closure of the isometry group was also investigated when the functions are continuous w. r. t weak* topology.

T.S.S.R.K. Rao

Algebraic number theory

Some surprising results on the unipotent algebraic groups in positive characteristic were obtained in collaboration with Mason, Premet and Zalesskii. These, applied to some earlier work on the congruence subgroup kernel in rank 1 groups over nonarchimedean local fields completely determine the structure of the congruence kernel, showing in particular that the structure depends only on the characteristic of the field and not on the algebraic group.

Polynomials $f(x), g(y)$ over a field K of positive characteristic for which $f(x)g(y)$ has a quadratic factor in $K[x, y]$ were determined -- in collaboration with Manisha Kulkarni. This is an analogue of a result of Bilu in characteristic zero with important applications to Diophantine equations. Again, in collaboration with Manisha Kulkarni, it was determined for any rational polynomial g and any $n > 2$, as to exactly when the Diophantine equations of the form $1 + x^{n^2/2!} + \dots + x^{n/n!} = g(y)$ have finitely many integral solutions x, y .

Research Activities

Certain formulae for powers of matrices found in an earlier collaborative work with James McLaughlin, were applied to prove that a procedure due to Khovanskii for finding m -th roots of positive integers works efficiently.

A theorem of Mity from 1836 on the decimal expansion of $1/p$ was generalized by interpreting it in terms of groups; this work was in collaboration with Ankit Gupta.

B. Sury

Real elements in algebraic groups

It has been proved that in classical groups (with some mild exceptions) and some of the exceptional groups (the adjoint ones), the real elements (elements conjugate to their inverses) are precisely those, which are strongly real (i.e. products of two involutions (order atmost 2 elements)). It has been proved that for any connected semisimple algebraic group with -1 in its Weyl group, the real strongly regular elements are strongly real. These results have significance in representation theory. It turns out that for the above groups, every self-dual representation is orthogonal. This work was done with the Ph.D. student, Mr. Anupam Kumar Singh.

Maneesh Thakur

Work done under the externally funded project

As a part of the D. S. T- N. S. F project, Extremal structures in Banach spaces, T.S.S.R.K.Rao visited the University of Iowa, Iowa city in May 2005 and the US-PI of the project Professor B. L. Lin visited the ISI at Bangalore in January 2006.

During these visits the collaboration has lead to the investigation of several new geometric properties. The most significant ones are the one dealing with ball proximality and new notions of smoothness called k -smooth and ω -smoothness.

T.S.S.R.K. Rao

Applied Statistics Division

The Applied Statistics Division came into being in September, 1996 in place of Applied Statistics, Surveys and Computing Division. The erstwhile Computer Science Unit was renamed as the Applied Statistics Unit and put in this division as its only unit while the Biometry Unit was transferred to the Biological Sciences Division.

Applied Statistics Unit

Scientists of the Applied Statistics Unit (ASU) are involved in various teaching, training, research and development activities. This unit regularly conducts teaching/training programmes like winter/summer schools, workshops and Probationers' Training for Indian Statistical Service Trainees. The members of the faculty conduct research in various areas of statistics, mathematics and computer science, with special emphasis on applications. Some members collaborate with other units of ISI on joint projects and also with scientists from other Universities/Institutes. Currently, there are collaborative on-going projects with the Theoretical Statistics and Mathematics Division, Computer and Communication Sciences Division and the Biological Sciences Division. The following were the main topics of research in the unit during 2005-06.

Sample surveys

The main research pursued relates mainly to developing (i) techniques needed to derive serviceable estimator when sampling effort has to be curtailed if resources do not permit continuation with the designs initially undertaken, (ii) techniques to employ appropriate estimation methods when Randomized Response (RR) procedures undertaken need to be adjusted if some respondents volunteer giving direct responses, (iii) Item Count Techniques as alternatives to RR techniques by way

Research Activities

of simplification of the latter, and (iv) alternative unbiased variance estimation techniques on working out first and second order Inclusion – probabilities in Rao-Hartley-Cochran (RHC) scheme of sampling.

Arijit Chaudhuri

District level estimates for 18 socio-economic variables utilizing NSS rural data for the 55th round have been provided. GIS techniques for statistical analysis have been explored. Rao-WU's bootstrap technique in unequal probability sampling has been extended.

Arijit Chaudhuri

Design of experiments, combinatorial methods and their applications

In fractional factorials, optimal main effect plans in designs with small blocks were obtained.

Mausumi Bose

Optimal crossover designs, which allow for premature termination of the experiment and optimal crossover designs when carryover effects are proportional to direct effects, were obtained.

Mausumi Bose

Reliability and survival analysis

A framework for estimating the distribution of quality-adjusted lifetime under some illness-death model was provided through parametric modeling. An improved calibration procedure for graphical comparison of two life distributions was proposed.

Anup Dewanji and Debasis Sengupta

A new model for software reliability was developed for the situation where failure is rare and there is no time-continuity of runs of the software. This model was used to evaluate the reliability of a unit of space vehicle flight control software, in the context of a project sponsored by ISRO.

Anup Dewanji and Debasis Sengupta

Inference procedures, exact and large-sample, for the Marshall-Olkin bivariate exponential distribution under concomitants of order statistics have been developed. A new parametric negatively dependent stress-strength model has been enhanced and an estimator of its unconditional reliability function has been studied.

Ashis SenGupta

Signal processing

Multivariate online change-point problems with distributions in possibly nonexponential families have been studied.

Ashis SenGupta

Strategies for estimating the extent of wear of a cutting tool using electrical signals from a face milling machine were studied, using experimental data from IIT Kharagpur. Demodulation of the current signal produced a waveform that bears resemblance with the cutting force, which determines the tool wear but is more difficult to measure in an industrial environment. This observation, together with a series of post-processing innovations led to a method that outperforms other existing methods in terms of empirical mean squared error. Comparison of various pre- and post-processing techniques with Force Power and current features was studied.

Debasis Sengupta

Multivariate analysis

The problems of classification and clustering of high-dimensional data was considered. Regularization of sample covariance matrices was studied theoretically as well as empirically in the context of the ongoing project on tiger pugmark analysis. The problem of determining the number of clusters – when there is a 'true' underlying cluster – was also addressed.

Debasis Sengupta

Research Activities

Admissibility and Bahadur optimality of LRT for Generalized Variance have been established. A classification rule based on Generalized Variance has been developed and demonstrated to produce encouraging results for Micro-array data analysis in Bioinformatics.

Ashis SenGupta

Statistical Inference

A new class of distance leading to robust and efficient minimum distance estimation has been proposed and the properties of the corresponding estimators and tests have been studied. The method of finite differences has been further developed to derive new and powerful goodness-of-fit tests, which applies to most growth curve models.

Ayanendranath Basu

Response-adaptive designs are extended to different real situations. Further works are done on response-adaptive designs with covariates in a phase III clinical trial set up. Optimal adaptive designs for binary data, continuous data and survival data are under study. Some works are also attempted on Meta analysis in this context.

Atanu Biswas

Some modification of Orban-Wolfe partial sequential procedure was suggested earlier. The properties of the proposed procedure are studied in detail. The results are compared with existing competitors.

Atanu Biswas

Some robustness related work is carried out for multivariate mixed discrete and continuous data.

Atanu Biswas

P^3 tests have been enhanced as Intersection-Union: Union-Intersection tests with applications to testing Bioequivalence. Sequential multi-parameter change-point problems have been studied from optimality aspects. Inference procedures for rates of growth based on Growth-curve analysis have been developed. Non-parametric estimator for a bivariate distribution under concomitants of order statistics has been derived. Linnik and other heavy-tailed distributions and related minification processes have been studied.

Ashis SenGupta

Probability Inequalities

Some new results have been derived in connection of the U-conjecture, and some special cases of these have been established.

Ayanendranath Basu

Categorical data

Some work on the measures of association for nominal categorical data was carried out.

Atanu Biswas

Time series of categorical data (both nominal and ordinal) was also done. Some non-stationary processes have been developed.

Atanu Biswas

Odds ratio has been theoretically studied under some situations where the usual assumptions do not hold. Earlier this was done for multiple tables. Now some technique is obtained with a single table at hand.

Atanu Biswas

Cryptology

Time memory trade off attacks have been studied and implemented to a limited extent. Efficient implementation of elliptic curve cryptography has been done. Algebraic attacks & algebraic immunity have been studied. New universally one-way hash families have been constructed. An algorithm has been developed for key pre-distribution in sensor networks.

Palash Sarkar, Subhemoy Maitra and Bimal K. Roy

Research Activities

Three meaningful criteria for comparing Visual Cryptographic Schemes (VCS) were introduced and methods of constructing VCS from several classes of combinatorial designs satisfying the above criteria were obtained.

Paresh Sarkar, Subhamoy Maltra and Bimal K. Roy

Environmental statistics

Statistical methods have been employed to study severity of arsenic contamination in water in different parts of West Bengal. Also effectiveness of arsenic removal plants have been studied.

Bimal K. Roy

The effect of noise pollution on school children was under study.

Anup Dewanji, Ritabari Roy Chowdhury, Alanu Biswas and Gopai Krishna Basak

Some regression models and classification rules for directional data in environmental and ecological sciences have been enhanced.

Ashis SenGupta

Directional data analysis

Classes of probability distributions on certain manifolds have been considered and related inference procedures have been developed. Bayesian techniques have been enhanced for lacking the problem of "unknown" normalizing constants for some of these models. Change-point problems with asymmetric circular distributions have been studied. Robustness of the estimators of the parameters of several circular models have been investigated

Ashis SenGupta

Other areas

Some work has been done on the analysis of survey data on socio-economic mobility of SC population of some areas of West Bengal.

Anup Dewanji and Bimal K. Roy

Computer and Communication Sciences Division

The faculty members of the Computer and Communication Sciences Division are engaged in research in theoretical and applied areas of Computer Science and Technology. They always take active participation in teaching and training in B. Stat., M. Stat., M. Tech. (Computer Science) and M. Tech. (OR & OR) courses of ISI. They also supervise M. Stat. and M. Tech. projects/dissertations besides the supervision of Ph. D. theses. Many undergraduate and postgraduate students of Computer Science, Information Technology, Electronics and Telecommunication, Electrical Engineering, MCA and students of Bioinformatics courses from different universities and institutes undergo their vocational/semester training under the supervision of the faculty members of this Division.

Advanced Computing and Microelectronics Unit, Kolkata

Mobile computing

Ad hoc is a relatively new field in networking that has recently drawn considerable attention with the proliferation of small computerized devices like cellular phones, PDA, Laptops. Collision in communication is a major problem in such networks as they operate without any infrastructural support. A distributed algorithm has been developed for spatial time division multiple access (STDMA) technique appropriate for such networks. A lower bound is established on the length of the frame assuming a degree bound on the nodes. Also, a distributed energy efficient algorithm for node-based transmission power control has been developed. Simulation studies show that it performs better compared to the algorithms reported so far in terms of power saving.

Nabanita Das and Subhasish Bhattacharjee

Research Activities

In a cellular mobile network, channel assignment is an important problem. Efficient channel assignment strategies using the concept of coalesced CAP have been proposed which starts with a known demand. Small perturbations are accommodated in the demand with some rearrangement of the assigned channels. Simulation studies on the well-known *Philadelphia benchmark* problems show that the proposed algorithms perform better compared to the earlier ones both in terms of computation time and blocking.

Bhabani P. Sinha and Nabanita Das

One of the important problems in ad hoc networks is to find an efficient routing algorithm. A simple and efficient two-phase distributed algorithm is proposed which is based on the CDS (connected dominating set) approaches. Simulation of this algorithm has also been performed and the results indicate that the proposed technique outperforms earlier methods in terms of cardinality of the set and the number of message exchanges.

Jayasree Dattagupta

Geometric algorithms

The research in this area is mainly focused on different geometric optimization problems, with applications to facility location, mobile computing, GIS, etc.

In GIS, the constrained shortest path problem in 2D and 3D (polyhedral terrain) with obstacles is thoroughly investigated. Given a convex polygon, placing of a guard on its boundary to guard maximum area outside the polygon is studied and an $O(n)$ time algorithm is proposed, n being the number of vertices of the polygon. In the same environment, the placing of one and two base station(s) of minimum range to cover inside the polygon are also studied and efficient algorithms are proposed. The problem of placing more than two base stations for covering the polygon is under consideration.

Sasanka Roy and Sandip Das

In the context of mobile computing, efficient algorithms are designed and implemented for the 2-hop broadcast in 2D region. The weighted broadcast problem in linear radio network is also studied.

Gautam Das, Sandip Das and Subhas C. Nayak

Parallel algorithms related to fragment assembly in DNA sequencing

The key steps for DNA sequencing are shattering multiple copies (clones) of the whole genome into several fragments, and then performing fragment assembly to discover long stretches of genome. The overlapping fragments of the genome should ideally form an interval graph. Experimental inaccuracies usually creep in either with missing fragments, or non-contiguous fragments attaching together to form a chimera. Implementation of a sequential algorithm for recognition of interval graphs based on a special data structure called PQ trees has been completed. A sequential algorithm to determine the interval number as well as the interval representation of a few special classes of graphs has been designed and implemented. A parallel algorithm for this problem is being developed.

Susmita Sur-Kolay and Srabani Mukhopadhyaya

VLSI physical design automation

The technological advances in FPGAs (Field Programmable Gate Arrays) in terms of density, speed and performance, have mandated the need for very fast FPGA design tools. A method for accelerating the placement phase of FPGAs upto 50% compared to the best existing tool, and even additional improvement in quality of solution has been devised. The main thrust is on obtaining a very good quality initial placement, instead of a random one, and then performing nominal ultra low temperature simulated annealing thereby leading to reduction in time. It employs top-down balanced bi-partitioning to obtain a linear order of the blocks to be placed which are then mapped by a recursive space-filling curve function.

State-of-the-art FPGA architecture has multi-millions of gates in CLBs, RAMs and Multiplier blocks. This renders the FPGA floorplanning problem to be significantly different from traditional ASIC

Research Activities

floorplanning. A deterministic algorithm is proposed for unified floorplan topology generation and sizing for recent FPGAs. The algorithm is based on recursive min-cut balanced bi-partitioning followed by post-order traversal of the binary partition tree to produce a floorplan. The floorplan topology generation from the partition tree is of $O(n \log n)$ time complexity, n being the number of modules. The topology thus generated is mapped to the FPGA target device to obtain a feasible floorplan using min-cost max-flow based formulation. Experimental results on benchmarks demonstrate considerable speed-up over existing methods, with more than 90% CLB utilization on the average.

Susmita Sur-Kolay and Pritha Banerjee

Test methodology for power supply droop noise induced timing faults

Increasing power density in nanotechnology chips emphasizes the criticality of maintaining steady power supply, with diminishing voltage levels as well, to the device layers through multiple layers of metal on one hand. Delay sensitivity to power supply variation being also on the rise, the importance of reliable distribution of power is manifold. Based on the fault model for gate delay faults from power supply droop noise developed by us earlier, a simple ATBG-based methodology to generate test patterns for detection for droop induced transition faults in a given combinational circuit has been designed and implemented. Experimental results on ISCAS-85 benchmark circuits reveal that very good droop fault coverage can be obtained by the small set of test vectors generated. Additionally, droop fault test sets yield high stuck-at fault coverage.

Test generation for transition faults in full-scan sequential circuits is a non-trivial problem. A novel methodology has been proposed for solving this problem and implementation of the scheme is in progress.

Finally, an efficient closed form analysis is proposed for faster simulation of droop in power grid. The time complexity of this algorithm is $O(\max(M^2, M^{2n} \log(n)))$ where an $M \times M$ matrix represents the equivalent RLC circuit for the power grid and n is the number of iterations, whereas that of traditional Modified Nodal Analysis (MNA) is $O(\max(M^2, M^{2n}))$. So for medium sized grids, our algorithm works better for simulation of many time steps.

Susmita Sur-Kolay, Debasis Mitra and Sandeep K. Dey

Design of scan path architecture

A complex VLSI chip requires several design-for-testability (DFT) techniques to ensure reliability. Designing energy-efficient scan path architecture with an aim to reduce test data and test application time is one of the major objectives of such DFT efforts. Various tree-based scan architectures have been studied for this purpose. A new structure called double-tree scan is introduced and evaluated for several benchmark circuits. Other tree-based architectures, which are suitable for today's compact test set, and layout-aware Illinois scan have been investigated. For response data compaction a linear space compactor is specially designed for such tree architectures that offers almost zero aliasing of errors. Our theoretical analyses and experimental results demonstrate that the proposals have strong potential for reducing test data and test application time drastically in embedded cores without comprising fault coverage.

Bhargab B. Bhattacharya

Multi-mesh architectures

The Multi-Mesh network was originally introduced by this research group in ISI. It provides a better architecture over the usual 2D mesh or torus. The basic scheme of Interconnecting the processors in a Multi-Mesh has been generalized to connect any number of nodes, i.e., it becomes incrementally extensible. It can be very effectively used in WDM (wave division multiplexed) optical networks because of its interesting feature of lower call blocking probability. Simulation studies have been made that support the theoretical claim. An extension of the basic architectural idea is proposed to design a 3D Multi-Mesh network. The topological features of this network have been studied and various algorithms have been mapped on this architecture with increase in overall execution speed.

Bhabani P. Sinha

On-chip implementation of Image processing algorithms

Real-time content-based Image retrieval (CBIR) problem is addressed which requires fast evaluation of feature vectors and matching for decision. Several novel techniques of characterizing an image along with algorithms based on computational geometry and data mining are used to implement the tool on chip. Parameters like Euler Number, Euler Vector, geometric distribution of control points, isothetic polygonal cover, corners with edge directions, have been considered for characterization and analysis of an image, with subsequent applications to indexing and retrieval. Applications to archival database searching, fingerprint matching, and feature data reduction have been studied. New techniques for torn paper matching have been developed, with applications to forensic science. Polygonal approximation of various shapes and its applications to CBIR has been investigated. This work is currently being pursued under a collaborative project with MIU, ISI and Intel Corporation, USA. Nine patents have been filed at the US Patents and Trademark Office.

Bhargab B. Bhattacharya

Checkpointing in distributed systems

Checkpointing is an important feature in distributed computing systems. It gives fault tolerance without requiring additional efforts of the programmer.

The checkpointing techniques, considered in this project, do not require any intervention from application programs. The system automatically takes checkpoints according to some predefined policy (outcome of our research). Moreover, the policy helps to recover automatically after any of the failing processes restarts. Relieving the application programmers from writing the complex and error-prone chores of implementing fault tolerance is the most promising advantage. Additionally, the system reliability is taken care of by the checkpointing schemes.

Traditional message passing based checkpointing and rollback recovery algorithms perform well for tightly coupled systems. In wide area distributed systems these algorithms may suffer from large overhead due to message passing delay and network traffic. Mobile agents offer an attractive option for designing checkpointing schemes for wide area distributed systems. In this work, a mobile agent-based checkpointing protocol is proposed for arbitrary network topology. Processes take logical checkpoints. The protocol can handle multiple concurrent initiations of checkpointing. At most two-checkpoints (one permanent and the other temporary) have to be saved in the stable storage of a process. Each initiator creates a mobile agent. An agent moves along a DFS tree rooted at the creator of the agent. A total of $O(n^2)$ moves and $O(n)$ time, n being the number of processors, are required by all the agents in the complete checkpointing process. This is an improvement over $O(n^2)$ messages in existing algorithms.

If the variables used for the checkpointing algorithm have data faults, the algorithm may fail. In this work, a self-stabilizing checkpointing algorithm is proposed for handling data faults in a ring network. The proposed algorithm can deal with concurrent initiation of checkpointing and at most one data fault per process. However, several processes may be faulty. For the proposed algorithm the worst case time and message complexities are both $O(n)$. An interesting extension is to consider multiple data faults per process and/or a general topology.

Krishnendu Mukhopadhyaya and Partha S. Mandal

Sensor networks

If the sensors are moving, finding locations of the sensors is a dynamic problem. Updating the locations involves invoking localization calls, which are expensive in terms of energy, a resource that is of paramount importance in sensors. A new Interpolation based technique is proposed for localization. Simulation results show significantly lower consumption of energy, over the existing extrapolation based techniques, keeping the error level same. However, the proposed technique cannot be used if the locations are required to be real-time.

Krishnendu Mukhopadhyaya

Research Activities

Computer Vision and Pattern Recognition Unit

Document analysis

To handle printed artistic documents a modified system towards the segmentation and recognition of multi-oriented and curved documents has been developed. A lexicon driven segmentation-recognition scheme for unconstrained Bangla handwritten city-names is developed for Indian postal automation. At present 84 different city-names and for each city-name class at least 100 samples are considered. An accuracy of 87.21% has been obtained from the system. In a multi-lingual and multi-script country like India, a single text line may contain words of two or more scripts. For an automatic Indian postal sorting system development, it is necessary to separate different script words. For this purpose a system is developed for the word-wise identification of handwritten scripts written in Bangla and English, as well as in Oriya and English. A method for the extraction of foreground from background in low quality color document images is developed. A system for segmentation of touching symbols appearing in mathematical expressions is also developed. The method is not restricted to any numbers of symbols touching together. Moreover, the problem of neighboring symbols touching in different directions (vertical, horizontal, diagonal, etc.) can also be tackled by the proposed approach.

Umapada Pal, Utpal Garain and Bidyut B. Chaudhuri

Handwritten character recognition

Shape based features have been designed for recognition of handwritten basic characters and numerals of Bangla script, and of handwritten numerals of Devanagari script. Both MLP based and HMM based classifiers were used for the purpose. Also, a two-stage MLP based scheme for the recognition of handwritten Bangla basic characters has been developed using direction code histogram based features. Recognition of handwritten Bangla vowel modifiers has also been investigated. For this purpose, a recognition scheme based on Gaussian and Beta mixture models has been developed.

A semi-automatic form processing approach has extensively been tested on our handwritten form image database. It has been found that the most difficult aspect of the problem is binarization of input form image. The existing binarization algorithms (including Otsu's method) have been found to be inadequate in our problem. A modification of Otsu's algorithm has been proposed which provides acceptable binarization results on our form image database.

A modified MQDF based system for Bangla handwritten character recognition and a modified system for Oriya handwritten numeral recognition have been developed.

Ujjwal Bhattacharya, Swapan K. Panu and Umapada Pal

Natural language processing

A study has been started on enumeration of multi word expressions (MWEs) of Bangla language. If several consecutive words in a sentence behave like a unified syntacto-semantic entity, they form together a multiword expression. The MWEs are acknowledged to create serious problems in the development of NLP technology. Bangla language text is replete with MWEs, especially with various forms of reduplicative words. A paper on the analysis of Bangla MWEs was accepted and presented at an International Conference on NLP (ICON) at IIT, Kanpur. Another work advanced to some extent during this period, is the readability analysis of Bangla text based on some experimental study with a few subjects. A new expression for readability of Bangla text has been proposed. This work was accepted and presented in an International Conference (ICCPB) at Independent University, Dhaka, Bangladesh.

Bidyut B. Chaudhuri, Sharmita Ghosh and Champa Kar

Digital data compression and security

A method has been implemented for lossless compression of Indian language textual images. The study is an extension of the previously developed pattern matching and substitution (PM&S)-based method for lossy compression of similar images. Here, an efficient technique for residual coding has

been proposed and its performance has been compared with CCITT Gr-IV and JBIG Compression technique. A set of 20 text images for two most popular Indic scripts, namely Devanagari (Hindi) and Bengali, has been used. The best results have been achieved by PM&S-based approach followed by LZW-based residue coding. For the text data, this combined scheme gives lossless compression ratio of about 37.8.

Another study has dealt with automatic summarization of text from JBIG2 coded textual images without doing optical character recognition (OCR). The compressed images have been partially (less than 10% of the uncompressed image size) decompressed to compute features determining the summary sentences. In addition, sentences are ranked within the summary. The experiment was conducted on Indian language text images. Test results show a sentence selection efficiency of about 56% when judged against summarization generated by human. A nonparametric (distribution-free) rank statistic has shown a correlation coefficient of 0.28 as a measure of the (minimum) strength of the associations between sentence ranking by machine and human.

Watermarking of documents compressed using lossy symbolic compression approach is another area of study. Its performance against various image processing operations has been examined. The method has been found to be perfectly resistant to JPEG compression and reasonably tolerant to scaling and addition of noise. A slightly different technique has been adopted for lossless symbolic compression, and its performance is being examined extensively.

Utpal Garain and Sarbani Pati

Information retrieval

Work on cross-lingual information retrieval from Indian language documents continues. The process of collecting preliminary relevance judgements for a test collection constructed earlier has been completed. The *n*-gram-based transliteration module reported earlier has been refined; its application to proper noun identification for languages which do not have public-domain POS taggers has been explored. The effectiveness of various methods for identifying multi-word indexing units is being explored. A survey of retrieval techniques for XML documents is near completion.

Mandar Mitra, Prasenjit Majumder and Sukomal Pal

Speech analysis and synthesis

Modification of Bangla Grapheme to Phoneme Dictionary consisting of 60,000 words has been done in this year. Some recorded speech data (about 400 minutes) have been collected from various sources. The data have been segmented into words (over 6000 words). Some analysis (i.e. study of variation of amplitude, pitch and duration) has been done for these segmented words for implementing a correct prosody required to produce natural speech. Inclusion of intonation pattern into the Bangla Grapheme to Phoneme Dictionary has been done so far on about 2000 most frequently uttered Bangla words. A tour to TIFR, Mumbai (21st March- 31st March) was arranged for the project worker to learn the Formant based speech synthesis.

Bidyut B. Chaudhuri

Electronics and Communication Sciences Unit

Bioinformatics

A novel scheme for designing fuzzy rule based classifiers for gene expression data analysis has been proposed. A neural network based method has been used for selecting a set of informative genes. Considering only this selected set of genes, exploratory data analysis techniques have been used to extract and refine fuzzy rules. The system has been tested on a leukemia data set containing two classes and it has been found to produce excellent results. The membership functions associated with the rules have been further analyzed and the rule base has been simplified without compromising the classification accuracy. The most attractive attributes of the proposed scheme are: It is an automatic extraction scheme; unlike other classifiers, it produces human interpretable rules, and it is not expected to give bad generalization as fuzzy rules do not respond to areas not represented by the training data.

Research Activities

There are many amino acid hydrophobicity scales available in the literature. Consequently a user/researcher faces the following questions: Are all these scales correlated, as one would expect? Is there a scale that is representative of a subset of scales? Which is the best scale among these? In this investigation these questions have been tried to answer. These scales have been analyzed using statistical tools, neural networks and fuzzy set theoretic algorithms to derive some consensus scales among them. The effectiveness and superiority of these newly derived scales have been demonstrated for solving the protein fold prediction problem.

Nikhil R. Pal

Neural networks

The concept of regularization has been incorporated into online feature selection neural networks. Such networks can select important features while learning the recognition task, and can easily avoid correlated features and features with very weak discriminating power.

Nikhil R. Pal

Mathematical morphology

A region based fusion algorithm has been developed for multifocussed images, where focused regions have been detected through granulometric analysis using morphological filters.

Bhabatosh Chanda

Image compression

Work on image compression was being carried out using vector quantization (VQ). Algorithm for accelerating codebook searching in a SOM based vector quantizer has been developed.

Bhabatosh Chanda and Nikhil R. Pal

Content-based Image retrieval

A system for content-based image retrieval has been developed based on low-level visual features like shape, texture and color. Search has been made efficient by indexing using primary keys and range search. Result has been improved by exploiting relevance feedback based on the outcome of Mann-Whitney test.

Bhabatosh Chanda

Document Image processing

Algorithms for Table of Contents (ToC), index pages and math-zone detection were developed and their performance has been evaluated over a large database.

Bhabatosh Chanda

Object tracking in video sequences

Both geometric and parametric active contour based object tracking in video sequence were investigated in detail. A novel technique for open-ended curve evolution in segmenting 2D thin filament like structure was developed. The algorithm is targeted for detecting road like structures in 2D satellite images or segmenting images of blood vessel like structures relevant to a number of biomedical applications. This algorithm has been adjudged as a part of the best dissertation award for M. Tech. (Computer Science) students.

Dipal P. Mukherjee

Video Image processing

A technique for key frame estimation in video was developed using complete spatial randomness measure of patterns. It was shown and reported that the relationship between different image features, both in the spatial and frequency domains, can be used to measure the randomness of the image content. The algorithm is under review with a reputed journal.

Dipal P. Mukherjee

Wave propagation and communication

It has become necessary to use frequency above 10 GHz to avoid congestion in UHF and lower region of microwave bands. During rain, the radio waves in these bands are subjected to attenuation and deterioration of performance. In an investigation with a 13 GHz link in the coastal region, it has been observed that a substantial amount of signal loss occurs during rain. In another investigation (jointly with NPL scientists) regarding estimation of attenuation of radio waves, it has been found that an increase in frequency (GHz) resulted in a higher attenuation due to presence of cloud.

Arun K. De

Machine Intelligence Unit, Kolkata**Pattern recognition**

The problem of clustering data into a fixed and variable number of clusters in both crisp and fuzzy domains has been tackled using genetic algorithms and simulated annealing. The application of a new multi-objective simulated annealing algorithm, in addition to multi-objective genetic algorithm, is also investigated in this regard. A new distance measure is proposed that takes the point symmetry property of the data into account. The clustering algorithm developed using this measure is found to yield good performance for both convex and non-convex clusters. New validity measures are being formulated in this regard. Another two level clustering algorithm is proposed that first exploits the concept of multi-class membership of the points to detect points on the class boundaries, and then performs the clustering.

Sanghamitra Bandyopadhyay

A genetic algorithm based approach to outlier detection has been developed. The essential idea behind this technique is to define outliers by examining those projections of the data, along which the data points have abnormal or inconsistent behavior, defined in terms of a sparsity factor. A partitioning method is used to divide the data set into groups such that all the objects in a group can be considered to behave similarly. Then those groups are identified which contain outliers. A new data structure, called the grid count tree (GCT), is used in this regard. The proposed method is applicable to both numeric and categorical attributes. Results for both artificial and real life data sets demonstrate the superiority of the proposed method.

Sanghamitra Bandyopadhyay

A fuzzy aggregation based new classification algorithm has been reported. Genetic algorithms are used in k-medoid based clustering schemes to design a new clustering technique. The technique is computationally less expensive than the existing k-medoid based clustering algorithm.

Ashish Ghosh

A connectionist system where the input features are taken from the frequency domain has been developed to automatically classify sodar patterns. The results demonstrate the effectiveness of the proposed model.

Swati Choudhury and Sushmita Mitra

Data and web mining

A fast algorithm for prototype selection and neighbour searching in the context of data mining has been developed. The utility of the algorithm has been demonstrated on several real life data sets. The performance of the algorithm is found to be better than the existing ones.

C. A. Murthy and Sankar K. Pal

An iterative algorithm has been developed for learning the support vectors using probabilistic principles. The results on several artificial as well as real life data sets demonstrate that the proposed method finds the support vectors properly.

C. A. Murthy and Sankar K. Pal

Research Activities

Attempts are being made to develop an algorithm for finding the category of web pages using neural networks.

C. A. Murthy

A new surfer model incorporating topic continuity among connected web pages has been developed. Also, a fuzzy surfer model based on the theory of fuzzy Markov chains is being developed. Novel methods for comparing rankings have been proposed and fast implementations are being developed for applying these methods to rankings produced by surfer models on large web document collections.

Sankar K. Pal

Symbolic fuzzy classification has been made using fuzzy radial basis function network, with fuzzy c-medoids clustering at the hidden layer. Symbolic objects include linguistic, nominal, boolean, and interval-type of features, along with quantitative attributes. This can be directly extended to multimedia data. Classification and clustering in this domain involve the use of symbolic dissimilarity between the objects. Fuzzy memberships are used for appropriately handling uncertainty inherent in real life decisions. The fuzzy radial basis function (FRBF) network here comprises an integration of the principles of radial basis function (RBF) network and fuzzy c-medoids clustering, for handling non-numeric data. The optimal number of hidden nodes is determined by using clustering validity indices, like Normalized Modified Hubert's statistic and Davies-Bouldin index, in the symbolic framework. The effectiveness of the symbolic fuzzy classification is demonstrated on real life benchmark data sets. Comparison is provided with the performance of a decision tree.

Sushmita Mitra

Multi-objective genetic algorithms are used for tasks such as classification and clustering in the context of data mining. Cost functions like rule interestingness, predictive accuracy and comprehensibility associated with rule mining tasks are treated as multiple objectives. Similarly, complementary measures like compactness and connectedness of clusters are used as two objectives for cluster analysis. Experimental results show that multi-objective genetic algorithms bring a clear edge over the single objective ones in the case of classification task; whereas for clustering task they produce comparable results.

Ashish Ghosh

Bioinformatics

A variable string length GA based technique for ligand design has been developed using local search heuristics, and improved encoding strategy. Its real life utility is being studied. The problem of gene ordering has been tackled using genetic algorithms and a heuristic search technique. Results show significant improvement over other methods.

Sanghamitra Bandyopadhyay

An attempt is made to employ hybrid genetic algorithms to solve the flexible-ligand docking problem i.e. predicting the binding conformation of a flexible ligand molecule into a rigid protein. It uses the concept of Lamarckian genetics to perform a local search about an individual. Two local search schemes have been investigated and their performance relative to the standard GA has been compared. Preliminary results obtained on a set of three protein-ligand complexes have shown promising results.

Ashish Ghosh

A methodology involving clustering on gene expression and fold values followed by determining similarity/dissimilarity among various clusters is proposed for finding over/under expression of genes. From this analysis, several genes have been identified which have significantly changed their expression values for asthmatic condition. Some of these observations are supported by some earlier investigations. Others have been stayed unnoticed so far, but may play crucial role in mediating the development of asthma.

Rajat K. De

An algorithm for modularizing signal transduction network is proposed. The methodology is applied to MAPK and calcium signaling networks, which are reduced to smaller and less complex networks. The

Research Activities

Idea that "a member whose function is controlled by maximum number of other members tends to be the center of a module" is used to divide a network into different modules. These modules are created by taking a certain level of complexity into account, i.e., in an expanding module, a member having more than two relations that lie outside the module, are ignored. Recursive modularization can create modules at different stages of various complexities that finally leads to convergence of the entire network into a single module.

Rajat K. De

Two connectionist models have been developed for describing the dynamics of gene expression incorporating protein concentration. The models are based on an existing theoretical model. The concentrations of mRNAs and proteins have been calculated at different time steps. The concentration of mRNA in a cell at a time step n depends on the concentration of mRNA and proteins at the time step $(n - 1)$ in that particular cell. Similarly the protein concentration in a cell at a time step n depends on the concentration of protein and mRNA at the time step $(n - 1)$ in that particular cell. The parameters are estimated using neural network models through learning. Finally, gene regulatory networks are determined as network parameters. The performance of the models has effectively been tested on a real life fruit fly time series gene expression data containing various stages of development of fruit fly.

Rajat K. De

Evolutionary computing, rough sets, artificial neural networks and soft computing

Particle Swarm Optimization (PSO) is an evolving technique for optimization. A modification is introduced in the basic algorithm of PSO which ensures convergence to the optimal solution. Additionally, the mathematical proof for the convergence has also been derived.

C. A. Murthy and Sankar K. Pal

In the context of Multi-objective Genetic Algorithm (MOGA), attempts are being made to construct generalized data sets that would help in comparing the performance of the several MOGA algorithms. It has been a long felt need in the literature to construct such data sets.

C. A. Murthy and Sankar K. Pal

New genetic operators have been developed for solving hard permutation problems like the Traveling Salesman Problem. Application to microarray data has been investigated. An improved model of multiobjective GAs that incorporates a new domination distance factor has been developed. Comparison with several well-known techniques has demonstrated the superiority and robustness of the proposed method over the others. A new model of multiobjective simulated annealing has been developed, and its application to solving the flip-flop clustering problem for buffered clock tree synthesis in VLSI has been studied. A new multiobjective optimization method based on particle swarm optimization is being developed.

Sanghamitra Bandyopadhyay

A new concept of ranking among the solutions of the same front, along with elite preservation mechanism and ensuring diversity through the nearest neighbor method is proposed for multi-objective genetic algorithm. This algorithm is applied to a set of benchmark multi-objective test problems and the results are compared with that of NSGA-II (a similar algorithm). The proposed algorithm is seen to over perform the existing algorithm.

Ashish Ghosh

Image processing and computer vision

A new algorithm for finding edges in colour images has been developed. The developed procedure would find edges in colour images without any tuning of the parameters. The developed algorithm has been found to provide satisfactory results on several hundreds of images. The performance of the developed algorithm is found to be better than the existing algorithms.

C. A. Murthy

Research Activities

Two methods of object recognition have been developed for colour images. One method uses clustering whereas the other method uses edge detection, for finding the features. The performance of these two methods has been tested successfully on the publicly available data sets namely, SOIL, COIL and ALOI. The methods have also been found to be better than the existing object recognition methods.

C. A. Murthy

New digital watermarking algorithms based on bi-orthogonal wavelets and M-ary modulation techniques have been developed. It has been shown that M-ary modulation along with QCM Scheme can further improve the hiding capacity. Proper choices of modulation function and signal decomposition tool can greatly improve the data insertion capacity, robustness and imperceptibility of the watermarking scheme. A new scheme based on genetic algorithms for covered image communication with optimal imperceptibility in a noisy channel has been developed. The method is found to be robust against most of the linear and non-linear filtering operation, noise addition, lossy compression and small rotation. A low cost watermarking scheme for printed image document has also been developed which can easily be tuned for different combinations of printer and scanner. The system is capable of detection and making the necessary correction for small rotation.

Malay K. Kundu

A new methodology for detecting corners in a gray level image based on fuzzy set theory has been developed. An inexpensive content-based retrieval of color images based on texture, shape and color information around visually significant points (detected using fuzzy model) has also been developed and tested on large benchmark databases of images. The results obtained are encouraging.

Malay K. Kundu

Tracking through snake model plays a significant role in image processing and computer vision. Different techniques have been developed so far but each has its own merit and demerit. Different aspects of a snake model are examined that has wider flexibility. The new snake model that is under investigation has many interesting features and efficient application ability.

Sambhurath Bhowe

Wavelet based feature extraction techniques are used for land cover classification of remotely sensed images. A new fuzzy aggregation based reasoning technique is developed for pattern classification with demonstration to remotely sensed image classification.

Ashish Ghosh and B. Uma Shankar

The problem of image object extraction in the framework of rough sets and granular computing is addressed. A measure called "rough entropy of image" is defined based on the concept of image granules. Its maximization results in minimization of roughness in both object and background regions; thereby delimiting the threshold of partitioning. Methods of selecting the appropriate granule size and efficient computation of rough entropy are described.

Sankar K. Pal and B. Uma Shankar

A wavelet based multiresolution fuzzy clustering of digital images has been developed. Wavelet transforms have been applied to decompose the images into different subbands in multiple resolutions, thereby eliminating noise in each low frequency subband. A combination of texture, shape, topology and fuzzy geometric features, that is invariant to orientation, scale and object deformation, are extracted from the low frequency subbands of the transformed image in coarser to finer resolutions. Partitive fuzzy clustering is performed, to group these images according to similarity at different levels of resolution. Clustering validity indices have been used to determine the optimal number of image categories. The images in each cluster are graded based on their distances from the corresponding centroid. The extracted features serve as the signature of the images, in terms of their content. Their use in content-based image retrieval is demonstrated. The relevance of the multiresolution technique to clustering and retrieval of images in the compressed domain is also highlighted.

Sushmita Mitra

Physics and Earth Sciences Division

This division comprises Geological Sciences Unit and Physics and Applied Mathematics Unit. Research is the main thrust of the division. However, scientists are also engaged in teaching various courses in the B.Stat. and M.Tech. programmes and in the ISEC. They guide and supervise research students towards Ph.D. degrees. Advanced courses and seminars are held throughout the year. A collaborative effort is also going on between the two units, on research projects of interdisciplinary nature.

Geological Studies Unit

Evolution of the Nallamalai fold belt (NFB) – fault reactivation and kinematics

Punctuation in down-temperature fabric development in the syntectonic Vellaturgranite along the eastern margin of the Nallamalai fold belt (NFB) has been analyzed. Relative rate of cooling and deformation seem to control the hiatus between magmatic fabric and Y-maximum quartz c-axis fabric and myrmekites representing intermediate temperatures. Gradation to low temperature fabric is indicated by abundant prism subgrain boundaries in quartz. Deformation along the eastern margin of NFB thus involved a deeper level of the crust compared to the western margin in the vicinity of the Rudravaram line where calcite mylonites show strong asymmetric calcite c-axis fabric, but Nallamalai quartzites are non-mylonitic.

Dip Saha and Sukanya Chakraborty

Calcite mylonites and thin-skinned tectonics in the NFB

Strongly asymmetric low-temperature (< 300°C) calcite c-axis fabric evolved under crystal plasticity (e-twin; r-slip) have been measured and analyzed from the Palnad calcite mylonites derived from Neoproterozoic Narji Limestone and comparable material near Rudravaram line. The kinematic interpretation of c-axis fabric pattern and oblique grain shape fabric in calcite mylonites from these two domains confirm westward advance of tectonic front. This major thin-skinned thrust advance possibly related to Pan-African event and was achieved under apparent ESE-WNW subhorizontal maximum compression (plunge 5°-30°) as obtained from dynamic analysis of calcite e-twins.

Dip Saha and Sukanya Chakraborty

Neoproterozoic sedimentation and paleogeography of the Cuddapah basin

Extension of the Kurnool sea through the present north-eastern extremity of the Cuddapah basin to its south-western part right across the westerly convex north-south basin axis has been suggested from gross similarity in facies successions belonging to the Kurnool Group, observed in Palnad and Kunderu valley areas. The sedimentary packet in both the areas dominated by fluvial to shallow marine siliciclast dominated Banganapalle Quartzite conformably overlain by the thick carbonate dominant Narji Limestone, have been interpreted to have formed due to gradual shoreline retreat during rise in relative sea level. Low relief of the basin margin area and deposition beyond the immediate influence of dispersal system of terrigenous input is indicated by the development of a thick carbonate facies (Narji Limestone) without much of siliciclastic terrigenous input. A passive margin depositional setting of the Neoproterozoic sequence prior to tectonic juxtaposition and uplift of the Nallamalai fold-and-thrust belt has been proposed.

Dip Saha and Sukanya Chakraborty

Precambrian geodynamics in the East Indian shield

Structural setting of the granulite-migmatite-granite suite of Sunki, in the central sector, of the Eastern Ghats belt, has been established. Petrological studies indicate high-temperature metamorphism and partial melting in pelitic assemblages, producing peraluminous granites and migmatites.

Sanatendra Bhattacharya and A. K. Shaw

Research Activities

Mafic crustal xenoliths in the Eastern Ghats belt

Different types of xenoliths have been recorded from Charnockite-massifs of the different sector in the Eastern Ghats belt. These include hornblende-granulites, garnet-granulites and pyroxenites. Trace element distribution shows Arc signatures in three of the four suites, studied so far. The fourth suite, namely that of Chilka, shows signature of Oceanic island basalt.

Samarandra Bhattacharya and Prasanna Das

Proterozoic basin analysis: Chattiegarh and Pranhlta Godavari Valley basin

Detailed petrographic analysis of sandstones including volcanoclastics and pyroclastics, focused on the studies of provenance, has been taken up. The relationship between sandstone composition and sea level changes was tested. The sandstones were studied under transmitted as well as reflected light. The optical microscopic studies were supplemented by SEM-CL analysis to identify high temperature quartz grains (bright blue-CL) and low temperature quartz (reddish-CL), and to discriminate the grains derived from granitic, metamorphic, and volcanic source rocks by specific texture. The detritus were derived primarily from cratonic blocks and recycled orogens, and rarely from volcanic source. The sandstones showed significant changes in detrital composition at the sequence boundaries, indicating major changes in provenance – basin configuration. The welded tuffs are rhyolitic, and detailed chemical analysis suggested peraluminous composition of the parent magma that was generated through partial melting of pelitic rocks. The tuff includes almandine garnets of magmatic origin.

Sarbani Patranabis-Deb and Asru K. Chaudhuri

Vertebrate palaeontology

Analysis of the collected archosaur material from the Middle Triassic Denwa Formation of the Satpura basin, central India was continued. These bones were unearthed from the red mudstone of a new site at the western part of the Satpura basin. The preliminary identification indicated the presence of an erythrosuchid and a rauisuchid in the Denwa faunal assemblage.

A study on the shape analysis of temnospondyl skulls using bilaterally symmetric closed Fourier curves has been completed. Based on this, a comparison of the skull outlines of different metoposaurid populations of the world has been undertaken. It has been noted that the Indian metoposaurids show wide variation in their skull shape. A reconnaissance fieldwork in the Rewa basin has been undertaken. Fossil exploration in the red mudstone of the Late Triassic Tiki Formation shows the presence of new reptilian bones along with the already known reptiles indicating potentials of future study.

A study on the bone microstructure of *Lystrosaurus murrayi*, an Early Triassic therapsid from India and South Africa was carried out. The study revealed predominance of fibrolamellar bone tissues indicating rapid periosteal osteogenesis and an overall fast growth in the Indian and South African therapsids. Moreover, four distinct ontogenetic stages and an indeterminate growth strategy and a semi-aquatic lifestyle for *Lystrosaurus murrayi* have also been concluded. A faunal turnover during the Triassic-Jurassic (T-J) boundary has been noted in different parts of the world. In India, signature of such T-J transition seems to be present in the Pranhlta-Godavari basin, as only this basin has a complete terrestrial faunal succession from Permian to early Middle Jurassic. A detailed faunal analysis of the Triassic and Jurassic horizons of this and comparison of these fauna with those from the coeval horizons of the world shows a definite faunal shift from the late Triassic to early Jurassic period.

Dhrujati P. Sengupta and Saswati Bandyopadhyay

Sedimentology and palaeoclimatology of the Satpura upper Gondwana

Facies analysis of the Permian – Triassic Bijori-Pachmarhi-Denwa succession in the Satpura Gondwana basin has led to the identification of shallow lacustrine deposits in the middle and upper part of the Bijori Formation (late Permian) refuting the earlier meandering fluvial interpretation. The Triassic red mudstone-dominated Denwa Formation is characterized by sandstone bodies deposited from laterally stable, mixed- to suspend-load sinuous channels of a low gradient, low-energy, anabranching river

system. The intervening thick mudstone deposits, in contrast to the earlier understanding, were deposited not only from overbank flooding but also from progradational avulsive splaying. This avulsion model has been established as a unique explanation for the overwhelmingly mud-dominated fluvial succession (Ghosh et al., 2006).

As a sequel of the facies analysis of the Permo-Triassic non-marine Gondwana succession of the Satpura basin a Quantitative Provenance Analysis has been taken up. Analysis of a large number of palaeocurrent data collected from this succession has led us to identify the Precambrian rocks bordering the southern and the southeastern margins of the Satpura basin as the most probable source rocks that supplied the sediments for the Satpura basin fill. Petrographic analysis of the framework elements of sandstones following the Indiana, USA, school had so far indicated a plutonic to middle and upper rank metamorphic and granitic source for the three litho formations (i.e., Bijon, Pachmarhi and Denwa). Modal analysis data of all the three formations when plotted in the Qt-F-L and Om-F-Li diagrams indicate a "craton interior" to "transitional continental" (continental block) provenance. Clues for provenance derived from the mineralogical analyses (of feldspars and heavy minerals) and geochemical analysis (major elements, trace elements including REE) of sandstone and mudstone is consistent with the nature of the Precambrian source rocks straddling the southern margin of the basin.

Soumendra Nath Sarkar, Partha Ghosh, Pradip K. Maalik and Tapan Chakraborty

River dynamics of the Sub-Himalayan Alluvial Plain, NE India

This project was concerned with the study of Sub-Himalayan Rivers and related flood inundations in parts of Sikkim, West Bengal, Assam and Arunachal Pradesh, which is relevant to flood-hazard mitigation policies of this region. The study of the maps of the alluvial plain prepared over last hundred years and comparison with satellite imageries reveals a number of locations of major river channel shifts. It has been noted that a major change in river plan-form from meandering to braided is associated with many such relocations. Analysis of the digital elevation data reveals presence of geomorphic expression of a number of very large alluvial fans. The dynamic topography of this alluvial plain defined by the growth, decay and deformation of these large geomorphic elements appears to govern the channel relocation patterns. The field observations suggest that these elements have formed by at least four spatio-temporally distinct events of deposition and incision. The possible correlation of these events with global climatic events with the help of TL/OSL age data is presently in progress. The evolution of the upland catchment basins in response to the tectono-climatic events during the Quaternary period is being studied using digital terrain analysis techniques.

Partha Ghosh and Tapan Chakraborty

Micellar and microemulsion system

The influence of the size of the polar head group of nonionic surfactants (Brij)s vis-à-vis the replacement of AOT-molecules by them in the interface (i.e., the interfacial composition of mixed surfactant interface) on the solubilization capacity and percolation in conductance for (AOT + Brij)s/isooctane/water systems have been explained. More insight on the interfacial composition of the mixed interface has been depicted with the help of spectrophotometric studies using 7-hydroxycoumarin as the fluorophore. The difference in phase characteristics with special reference to the area of monophasic zone, appearance of mesophases, nature of polar solvents, content of nonionic surfactants (Brij-52, Brij-72 and Brij-92) have been investigated for ternary systems (AOT/heptane/FA, EG, TEG, GLY) at 303K. The area of monophasic domain has been found to be dependent on the nonaqueous solvents and follows the order, GLY>EG>PG>TEG. The threshold point of phase separation (both W1-WIV and WIV-WII) of these mixed systems stabilized in oils of different chain lengths (heptane, dodecane and hexadecane) and EG have been found to be a function of the configuration of the added nonionic surfactant, nature of the polar solvent and oil. The appearance of the three-phase body (fish-tail model) confirming the establishment of HLB in the quaternary system, Brij-76/1-butanol/ isooctane/water at 303K. Addition of nonaqueous polar solvents (e.g. FA and DMF) altered the HLB of the systems and the fish appeared at a higher weight fraction of

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1-butanol. More pronounced effect for DMF than FA has been noticed. The results have been summarized on the basis of HLB and mutual solubility of the components.

Bidyut K. Paul and Rajib K. Mitra

Physics and Applied Mathematics Unit

Condensed matter physics

It has been shown that the newly observed families of Fractional Quantum Hall (FQH) states, when studied in the Berry Phase approach, can be well accommodated within the primary sequence and need not be considered as second generation FQH states.

A study of the charge and statistics of quasi-particle excitations in FQH states have been studied in this approach. It was shown that the deviation of fractional quantum Hall edge fluid from power law correlation functions with universal exponent $\alpha = 1/\nu$ as observed in recent experiments may be explained when studied in the framework of Berry phase. At the edge the non-local effect was induced in the construction of the electron creation operator in terms of the edge boson fields. This non-locality was responsible for the deviation of the power law exponent from $\alpha = 1/\nu$ of the edge fluid. These studies were carried out in collaboration with Professor P. Bandyopadhyay, former Professor of this Institute.

Another study exploited a quantum mechanical toy model was exploited for the study of Coulomb interaction in quantum Hall (QH) system. Our model simulated a bi-layer QH system in the compound state and it was shown that the non-commutative extension of the Coulomb term differs from its commutative counterpart in higher order in theta (θ) provided θ varies from layer to layer. This work has been done in collaboration with Dr. S. Ghosh of this Institute.

Banasri Basu

Classical optics

In a comprehensive analysis of the extinction spectrum for a single model size distribution of Mie particles, simple mathematical formulae and numerical methods were developed for easy applications in practical (experimental) situations. The novelty and significance of the analysis lay in its ability to explain accurately almost all the features, which are of concern to researchers from the physical standpoint. The utility has been demonstrated to be excellent. Modeling of size-distribution of galactic dust particle (silicate and graphite) from data on extinction of starlight using the above framework has been taken up. Some preliminary work has so far been done to assess the feasibility of the collaborative research programme. The problem involves bimodal distribution; hence, some extra care and efforts are needed. The collaborative work is on track.

An analytic solution for electronic states in a mesoscopic ring has been worked out. These solutions are to be used to analyze some experimental data in order to demonstrate their utility. Recently, many experiments have been done with quantum rings. The collaboration is under progress.

Asim K. Roy

Quantum entanglement and Information theory

A study was made on the influence of the Berry phase generated due to a cyclic evolution of an entangled state of two spin $1/2$ particles has been studied. It was shown that the measure of formation of entanglement is related to the cyclic geometric phase of the individual spins.

Banasri Basu

In quantum mechanics, there are many operations like cloning, deleting, flipping, and Hadamard gate, which cannot be applied in a universal way. These features of impossibility find interesting applications in quantum information processing. A connection between impossibility of universal flipping and the condition of no signalling as well as the principle of non-increase of entanglements has been established.

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The other topic of interest has been the connection of entanglement with nonlocality. Hardy's theorem regarding quantum nonlocality is being extensively studied even for mixed states and a comparison made with other results of Bell's inequality.

Guruprasad Kar

It is known that there does not exist a universal Hadamard gate for an arbitrary unknown qubit. Therefore, the most general ensemble of qubits, for which it is possible to design a universal Hadamard gate has been obtained. These states when geometrically represented on the Bloch sphere, gave a new trajectory. Unequal superposition of an arbitrary qubit and its orthogonal complement was also investigated.

Preeti Parashar

The theory of weak measurement and its relation to quantum computing is under investigation. The idea of ion trapping is under investigation so as to realize quantum computers in biological organism.

Sisir Roy

Quantum field theory

In the context of non-commutative quantum theory, various operatorial structures of noncommutativity have been studied, that are Lie algebraic in nature. In particular, point particle models for spatial coordinates obeying angular momentum algebra have been constructed. The model has also been embedded in Batalin-Tyutin extended (canonical) phase space. The relativistic generalization of this model is being pursued. The work was done in collaboration with Dr. Probir Pal.

Recently noncommutative spaces have been linked with problems related to Berry Phase in condensed matter physics. A new form of non-commutative phase space algebra has been provided that generates a singular effective magnetic field in coordinate space. It's possible connection to Anomalous Hall Effect is being investigated. These studies are being pursued in collaboration with Dr. B. Basu of this Institute.

Subir Ghosh

Cosmology

It has been suggested that Chaplygin gas can provide a model for Dark Energy that drives the accelerated expansion of the universe. The relativistic Chaplygin gas model has been studied and the conclusion reached does not agree with the existing results that are derived by considering a non-relativistic version of Chaplygin gas model. The work has been done in collaboration with Dr. R. Banerjee of S. N. Bose National Centre for Basic Sciences, Kolkata.

Subir Ghosh

Quantum mechanics

Lie symmetry, nonlinear algebraic symmetry and super-symmetric structure of position dependent effective mass Schrödinger and Dirac Hamiltonians respectively, were studied. Non-Hermitian interactions, in particular, PT symmetric ones have been studied in the framework of effective mass formalism. A systematic algorithm has been formulated for constructing a whole class of Hermitian position dependent mass Hamiltonian which, to the lowest order of perturbation theory, allows a description in terms of PT symmetric Hamiltonian.

Hidden symmetry structure of Non-Hermitian Hamiltonians which gives rise to a generalized quantum condition has been explored. Non-Hermitian interaction and higher order Darboux transformation have been studied in the context of Dirac equation. Nonlinear pseudo-supersymmetry and higher order intertwining operators for Non-Hermitian Hamiltonians are being studied in detail.

Pinaki Roy, Barnana Roy and Rajkumar Roychowdhury

Theoretical plasma physics

Sagdeev's pseudopotential approach has been used to study ion acoustic solitary waves in dusty plasma in a magnetic field. This study has been extended to the case where dust charge variation is taken into account in a proper way. The study of solitary wave solutions in plasma in non-planar

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geometry is another field, which is being actively pursued. Recently, study is being done on hydrodynamic models of quantum plasma.

Rajkumar Roychoudhry

High and ultrahigh energy physics

After an impressive success in the field of theory of heavy ion collisions in high energy nuclear physics and understanding the latest data from FERMILAB experiments involving hadron-nucleus interactions at high energies and modeling them, some old scaling ideas vis-à-vis the newest data available from CERN-experiments and RHIC studies have been tested. Studies on the applications of non-extensive thermodynamics in various high-energy collision processes has been taken up. Besides, asymptotic nature of total cross-section for multiple productions and the origin of the ultrahigh energy cosmic rays have been studied.

Subrata Bhattacharyya

Interacting fock space

Evolution of atom-field system in Interacting Fock Space has been studied for a two-level atom. Oscillatory population transfer (Rabi flopping) has been studied. The generalization of this coherent situation to driven three-level atoms leading to new phenomena, such as dark states and EIT, are being studied.

Pradip K. Das

Basic fluid flows

Industrial flow problems are modeled theoretically to understand the process in a better way for further development. In stretching sheet flow problem, it has been observed that the physical properties of fluid have a very strong effect on flow and heat transfer conditions. It is expected that these properties may also affect the coating problem. Under this assumption, further investigations have been proposed to study the coating problem on a rotating disk.

Bhabani Sankar Dandapat

Hydrodynamic stability and waves

Waves that develop on the surface of an inclined or vertical plane have been studied when linear variation of temperature field is introduced on the surface of the plane. One main objective has been to study the effect of thermo capillarity on wave formation.

Bhabani Sankar Dandapat

Laminar and turbulent flows

The major aim has been to construct physico-mathematical models for viscous laminar flows of Newtonian and non-Newtonian fluids of practical interest. Some improved models for turbulent fluid flows through pipes, channels and boundary layer over smooth and rough surfaces were sought to be developed. Emphasis was given to group-theoretic and similarity methods in solving these problems.

Himadri Pai Mazumdar

Computational Linguistics: The status of computational linguistics has been questioned here from the standpoints of (a) Philosophy of science, (b) Natural Science (mismatch between human cognitive domain and machine algorithms), (c) Social science (Plurilingual Planning), (d) Algorithmic (in contrast with post-format subjective and substantive task of Linguistics).

Debepuras Bandyopadhyay

Convective and diffusive transport

Longitudinal dispersion of passive tracer molecules released in a pulsatile flow through an annular pipe with reactive wall has been investigated by employing the method of moments. The study of longitudinal dispersion of a tracer in a straight tube has a wide range of applications in the field of chemical, environmental and biomedical engineering. Particularly, the results of present study are of

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great importance in understanding the dispersion process through a catheterized artery with a reactive arterial wall.

Bijay Singha Mazumder

Sedimentological fluid dynamics

Interdisciplinary research work on sediment transport involving fluid dynamists, statisticians and geologists has been carried out experimentally as well as theoretically in the Fluvial Mechanics Laboratory (FML) at ISI, Kolkata to understand the turbulent bursting processes, which are responsible for the sediment upliftment, size-sorting and transportation. The movements of particles associated with the turbulent flow near the boundary were recorded using high-speed motion scope (HSMC) and the data was analyzed using image-processing technique. As the particle movement is random due to turbulent flow, it would be interesting to develop a probabilistic model to analyze the image data.

Bijay Singha Mazumder

Dynamic geometry and brain function modelling

The idea of functional geometry and tensor network theory as proposed by Rodolfo Linares revolutionized our conception on Brain Function Modelling. In collaboration with Professor Linares (USA) the concept of dynamic geometry has been proposed, which will shed new light on network theory and the cognitive activities of brain.

Sisir Roy

Statistical metric and new measure of complexity

In collaboration with Professor Vito de Gesu (Italy) a new measure of complexity based on the idea of statistical metric by Karl Meuser has been proposed. Initially the results of existing measures have been compared with this new measure in case of astronomical images. Very recently, a group of psychologists and computer scientists from U. K. and Italy performed physiological tests to estimate perceptual time for three different paintings. The results have been compared and it is observed that the above results can be fitted only with the proposed measure. It would be interesting to look for the physical interpretation of this measure and also to get FMRI data for comparison.

Sisir Roy

Multivariable system and control theory

In this scheme, interest has been taken in developing computational methods for analysis and design of problems concerning multivariable control systems. Besides, problems on the control of some dynamical systems are under investigation.

Subrata Gangopadhyay

Linguistics-mathematics Interface

Although, in the history of linguistics, a continuity is assumed to consider General Grammar, Philology and Linguistics as a progressive development of study of language as object, there are epistemological breaks among these three. In Linguistics, there are three distinct thresholds: first The faculty members of the Computer and Communication Sciences Division are engaged in research in theoretical and applied areas of Computer Science and Technology. They always take active participation in teaching and training in B. Stat., M. Stat., M. Tech. (Computer Science) and M. Tech. (OR & OR) courses of ISI. They also supervise M. Stat. and M. Tech. projects/dissertations besides the supervision of Ph. D. theses. Many undergraduate and postgraduate students of Computer Science, Information Technology, Electronics and Telecommunication, Electrical Engineering, MCA and students of Bioinformatics courses from different universities and institutes undergo their vocational/semester training under the supervision of the faculty members of this Division.

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Biological Sciences Division

The Division comprises three units namely Agriculture and Ecological Research Unit, Biological Anthropology Unit and Human Genetics Unit.

The foci of current research activities include studies on biodiversity in multiple eco-systems, encompassing plants, animals and humans, as well as on human genome diversity in the perspective of evolution and disease. Faculty members of the division participate in teaching various courses of the Institute and are actively engaged in guiding Ph.D. students.

Agricultural and Ecological Research Unit

Studies on productivity, stability and sustainability of rain-fed agricultural systems in the eastern plateau area

Eco-friendly technologies with low inputs that are well suited to eastern plateau region having potential towards increasing and stabilizing productivity were evaluated and transferred to the farmers. The objective was to achieve livelihood through subsistent farming in the risk prone fragile ecosystem of the study area. Field trials undertaken during this period established low input appropriate technologies in subsistent farming in relation to crop management and increasing soil health through integrated nutrient management practices. New value added crops like baby corn have also been tried to be established in this area with appropriate package and practices. The improved low input technologies were diffused to farmers' fields through 'on farm' trials. Experiments had been conducted on farmers' plots in some villages of Giridih district.

Pabitra Benik and Prabir K. Ghosal

Adaptability and yield performance of sugar beet (*Beta vulgaris L.*) varieties in lower Gangetic plains of West Bengal

In India, sugar cane (*Saccharum officinarum*) was the only sugar-producing crop. Recently, another viable root crop sugar beet (*Beta vulgaris*) has been established in different states of our country. The major advantages of sugar beet over sugar cane are its short duration of growth, water efficiency, high sugar concentration and wide range of soil adaptation (from high alkaline to high saline). In West Bengal, multi-local trials with new varieties namely Posada, HI 0064 and Dorotea exhibited performances quite comparable with that of other states. Some photo-thermo insensitive cultivars supplied by the 'Syngenta (I) Ltd., has been tried in different agro-climatic regions of 24 Parganas (N) (like Bongaon and Bagda) through State Government Research Farms in Bongaon and Bagda region. These can be grown throughout the year with an average yield of 70 tones per hectre. Research indicates that in near future, sugar beet could be a potential source of industrial ethanol in our country.

Samarendra Banik and Sunanda Chanda

Ecology and physiological studies on the mangroves of Sundarbans

The vegetation pattern of Sundarbans changes dramatically from the shallow region to the upland portion of an island. It is an open challenge to both ecologists and statisticians to find out the very ecological reasons behind this varied zonation at different parts of the same island. The ecologists at present are unable to specify the precise causes in determining vegetation zonation. Recently it has been found that some important tree species of mangroves such as, *Avicennia tomentosa*, *Xylocarpus granatum*, *X. mekongensis* and *Nypa fruticans* are declining day by day at an alarming rate. In some islands a large central area has been devoid of any mangroves. The reasons behind it are not clear. In view of the above problems, certain physiological, biochemical and ecological investigations of mangroves for their adaptive status against salt stress, community structure, biomass production, nutrition, and the Mycorrhizal status of rhizospheres of mangroves of some islands of the Sundarbans have been undertaken.

Manoranjan Ghose, Sauren Das and Kausik Bhattacharyya

Studies on the ecology, conservation, propagation, and utilization of palms with special reference to rattans

The rattan palms (canes) form one of the most important Non Timber Forest Products (NTFP) in the Northeast Himalayas. The genus *Calamus* of rattan palms possesses about 52 species in Indian flora of which Northeast India contains the maximum number. The other rattan palms are *Karhalsia*, *Daemonorops* and *Plectocomia*. These palms, commercially, play an important role in the socio-economy of forest dwelling communities. The usage of rattan palms is manifold such as, preparation of various types of furniture, baskets, lampshades, interior decorative items etc. Although the canes, of which the 'Golla' (*Daemonorops jenkinsianus*) is endemic to the Northeast, are becoming increasingly rare due to unsustainable extraction and destruction of habitat, several areas in Barak Valley have been identified where canes are still available.

In view of the above, extensive surveys conducted in Cachar district, of the Barak Valley region of Assam, have revealed the existence of 9 species of canes. These include some 'rare' and 'very rare' species, which need to be conserved immediately through both in-situ and ex-situ methods. Mature seeds of *Calamus lenus* and *Calamus erectus* were collected and their mode of germination studied. It has been found that germination of seeds is almost 100% if the pulps of the fruits are removed before sowing. Seedlings raised in the nursery have been transplanted in the adjacent campus of Assam University. Some seedlings were distributed among the villagers for cultivation in their home gardens and near wetlands.

Manoranjan Ghose, Sauren Das, Kausik Bhattacharya and Abhik Gupta (Assam University)

Ponds, aquatic weeds and water quality: an Investigative study

Baseline data have been collected on twelve ponds to study the causes of phytoplankton versus macrophyte dominance/disappearance in ponds. From the data collected so far, it was found that most of the major nutrients (excepting DO and SRP) were much higher in ponds with algal blooms than in those with macrophytes. Chlorophyceae, Euglenophyceae and Cyanophyceae blooms were the three main categories observed of which there was a clear dominance of cyanobacterial algal blooms. In most cases the species number associated with cyanobacterial blooms was 3-12 while for the other types it was 1-18. If we differentiated between the Cyanobacterial blooms (harmful bloom types) and the non-cyanobacterial blooms (green algae or euglenoids), total phosphorus, soluble reactive phosphorus, nitrate nitrogen and ammonia nitrogen values were always higher in the cyanobacterial bloom ponds.

Anjana Dewanji

Study of the microbial succession and changing microbial molecular diversity of a bio-organic composting system

Compost prepared with vegetable waste, rice straw, dung and water was piled and heaped into a 2.5 feet high mound at Gupta Niwas, an experimental station of AERU, ISI. At different stages of composting, presence of microbial population in it was identified with the help of DAPI staining. From compost sample, chromosomal DNA was isolated; 16S rDNA was cloned and sequenced with the help of Polymerase Chain Reaction (PCR). Molecular biological analysis was done by fluorescence in situ hybridization (FISH) technique with the custom synthesized oligonucleotides for identification of organisms.

Sunanda Chanda, Samarendra Barik and Subrata Pal (Jadavpur University)

Mathematical models on ecology and epidemiology

It has been attempted to establish the role of different hydrological parameters in the formation of plankton blooms and to look for a suitable form of functional response to describe the reduction of zooplankton population due to toxin producing phytoplankton (TPP). The analysis of variance technique has been considered in regression model. It has been tried to check whether each of the zooplankton species has significant association with any of the physical parameters and TPP as a whole and each of the zooplankton species has any association with the physical parameters and the

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TPP individually. Moreover, a modified variance measure has been proposed for detecting species association, taking into consideration some of the environmental variables. Incorporating our findings into a mathematical model it has been shown that a sufficiently large increase in the toxin production rate can destabilize the plankton system's functioning and result in algal bloom. The deterministic and stochastic behaviour of the ratio-dependent predator-prey models system around biologically feasible equilibria, which entered into Hopf-bifurcation have been worked out. Stochastic stability of the system around positive interior equilibrium has been studied, and numerical simulations have been carried out for hypothetical sets of parameter values. The effects of the caloric content or a nutrient bound of prey on the dynamics of competitive coexistence with the shared predator in a specific model have been studied. Mathematical models have been proposed and analyzed for exploitative competition of two prey species with a shared predator. The changes of dynamic stability due to the variation of a nutrient bound of each prey on predator-mediated dynamics have been studied through extensive numerical experiments. The analytical and numerical results have demonstrated that variation in a nutrient bound promotes the switching of dynamics, which may be a driving force for the dynamics of competitive coexistence with the shared predator.

Jaydev Chattopadhyay

Biological Anthropology Unit

Health and disease among populations inhabiting contrasting ecological niches

The project aims at a comprehensive evaluation of health status of different ethnic communities inhabiting contrasting ecological settings and experiencing life style variations. Specifically, the study examines the effects of ethnicity and life style related factors on health, measured in terms of its important domains, among populations inhabiting contrasting ecological niches. Populations from Sikkim hills (Bhutia and Rai), Coastal Midnapore (Jelita Kaibarta) and Onssa plains (Shabar) are chosen as study populations from whom a large variety of data pertaining to different domains of health are being collected. The analyses of data so far reveal the following : (a) Significant difference exists in respect of fertility and infant mortality between Rai and Bhutia populations; (b) Significant difference in immunization coverage exists between the Rais and the Bhutias; (c) Rais and Bhutias experience significant differences in respect of prevalence of obesity and hypertension among the adults; Lipid Profiles of adults, however do not show significant difference; (d) Low prevalence of hyperglycemia is evident in both these ethnic groups; (e) Rural Shabars showed significantly higher infant and child mortalities compared with their urban counterparts; (f) Prevalence of chronic energy deficiency is higher among urban males, while the trend is reversed in case of females.

Suzmita Mukhopadhyay, Ranjan Gupta, Premananda Bharati, Barun Mukhopadhyay and Subrata K. Roy

Genomic diversity of Adi tribal cluster of Arunachal Pradesh

In recent years genomic diversity of tribes and castes in different regions are explored to get clarity of the origin, past genetic history of peopling of Indian subcontinent and affinity with global populations, however such studies are very few among the Tibeto-Burman (TB) populations.

TB is one of the four major linguistic groups exclusive to the northeast populations of India. Morphologically they show Mongoloid features and have migrated from southern parts of Tibet (China) in the recent past. They consists of several hundreds of tribes, reflect vast cultural and linguistic diversity, however the biological and genetic diversity and their affinity with other regional and global populations is little investigated.

In this regard this project investigates the origin, migration and past genetic history of the Adi sub tribes of Arunachal Pradesh and their affinity with other linguistic and ethnic groups in India and neighboring countries.

Adi tribal cluster consisting of at about 15 tribes living in central Arunachal Pradesh, possibly belong to a common ancestral population before their migration and settlement in different parts of Siang river valley in central Arunachal Pradesh. Though culturally and geographically recognized as different subgroups or sub tribes, the biological significance of sub tribes or affinity and diversity among them are of importance in population genetics. In addition, many of the sub tribes are remotely located in

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interior hills and valleys with least disturbance from the outside world. As such they are expected to provide opportunity for investigating the microevolutionary process.

The main objective of the study is to investigate the genomic diversity and affinity of the Adi sub tribes. Based on blood samples, (collected from the sub tribes of Adi from their remote villages), and typing for 15 autosomal loci, mtDNA and Y chromosome markers will be undertaken for tracing the maternal and paternal past genetic history of the tribes and their affinity and diversity with other tribes, castes of Dravidian, Austro-Asiatic and Indo-European speaking populations and with other Mongoloid tribes of eastern and southeastern countries.

T.S. Vasulu

Physical growth, body composition and nutritional status of the Bengali school aged children, adolescents and young adults of Calcutta, India: Effects of socioeconomic factors on secular trends

The study has been aimed with the purpose of investigating the magnitude of secular changes in the measures of body size, body shape, parameters of the adolescent growth spurt, body composition and nutritional status of the school aged, adolescents and adults in the Urban Bengali population of the Kolkata city. Collection of Socioeconomic data and Anthropometric data from 600 school and college girls and 300 school and college boys from Cakutta city aged 7-21 years, is complete.

Preliminary analysis based on partly collected data on the boys aged 7-16 years shows evidence of positive secular trends in the measures of average body size, in average body shape and in the prevalence of stunting, thinness, overweight and obesity over an interval of about two decades. Further data collection is in progress.

Parasmani Dasgupta

Status of Austro-Asiatic tribes in the peopling of India : Extension of our work on the Mon'Khmer tribes of India.

Through extensive analyses of the mitochondrial and Y-chromosomal DNA among most of the Austro-Asiatic populations of India, compelling evidence has been obtained to infer that the ancestors of the present day Austro-Asiatic tribes of India, particularly of the Mundari speakers from Chotanagpur plateau, are the parental source populations of all the present day Austro-Asiatic populations of the world, distributed predominantly in Southeast Asia. The evidence for back migration of Mon'Khmer (Nicobarese and Shompen) and Khasi Khmuic mongoloid tribes from Southeast Asia has been also found.

B.M.Reddy

DNA polymorphisms in the castes and tribes of Andhra Pradesh, India

Molecular genetic studies among the castes and tribes of AP highlights certain interesting features with reference to genetic stratification via-a-vis social stratification.

Based on the molecular genetic data in patrilineal and matrilineal populations of India, the study examined the universality of the hypothesized greater Y-chromosomal compared to mtDNA variability in patrilineal populations and found that given the unique population structure with rigid endogamy rules governing the marriages, this hypothesis does not fit to the Indian situation.

B.M.Reddy

HLA genes and recurrent spontaneous abortions

For the first time in India, a molecular study of HLA genes among couples with recurrent spontaneous abortions has been undertaken. The study will have considerable social relevance as the findings are expected to help in genetic counseling and in designing appropriate therapeutic measures.

B.M. Reddy

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Adolescent's reproductive health: Bio-cultural dimensions

Adolescents make up a large proportion of India's population. Their vulnerability caused by young age, their ignorance on matters related to sexuality and reproductive health, their lack of factual knowledge on contraception and inability or unwillingness to use health services put them at the risk of serious consequences. With objectives (i) to obtain information on knowledge and attitude on reproductive health, (ii) to assess the effects of socio-cultural dimensions on reproductive health and (iii) to assess the constraints they face in acquiring health services, the present study can provide greater insights into underlying risk factors and can help suggest some policy options.

Susmita Mukhopadhyay

Human Genetics Unit

Genomic reconstruction of the peopling of India

A study has been completed to address two debates concerning the peopling of the Indian sub-continent.

The first debate is regarding the sharing of genetic signatures between tribal and caste groups of India. One model suggests that the tribes and castes share considerable Pleistocene heritage (going back to about 60,000 years before present), with limited recent gene flow between them (Kivisild et al. 2003a), whereas an exact opposite view concludes that castes and tribes have independent origins (Cordaux et al. 2004).

The second debate concerns the origins of the hypothetical proto-Elamo-Dravidian language, which is thought to be the precursor of Tamil. It has been proposed that the proto-Elamo-Dravidian language spread eastward from southwest Persia into South Asia with agriculture (McAlpin 1974, 1981), and the argument is bolstered by the existence of a solitary Dravidian-speaking group, the Brahui, in Pakistan (Renfrew 1996). The linguistic evidence, however, is compromised by uncertainty regarding whether word borrowing is responsible for the observed linguistic affinities (Blazek and Boisson 1992). Some western Eurasian female-lineage (mtDNA lineage) genetic signatures found in India was interpreted (Kivisild et al. 1999) to support the hypothesis that Dravidian farmers arrived in India from the Middle East (Renfrew 1996). Since most Dravidians are geographically clustered, this scenario implies a farming-associated language shift in India. A competing alternative model based on both archaeobotanical material evidence and colloquial agricultural terms, however, more parsimoniously postulates that early Dravidian has a epipaleolithic (20,000 – 10,000 years before present) preagricultural heritage with origins near a South Asian core region, suggesting possible independent centers of plant domestication within the Indian peninsula by indigenous peoples (Fuller 2003).

To shed light on these debates, about 1100 independent Y-chromosomes were studied, at the highest resolution ever attempted. The Y-chromosomes were drawn from 36 geographically, socially and linguistically disparate ethnic groups of India, 8 ethnic groups of Pakistan, and 18 ethnic groups from the south-east Asian region. Each Y-chromosome was screened for about 80 genetic markers, of which 10 markers were actually discovered in the present study. The study has overcome some of the primary limitations of earlier studies, viz. inadequate representation of ethnic variation, inadequate genetic resolution, and inadequate use of statistical methods.

It is observed that: (a) The majority of the genetic signatures found among the males in India are older than 10,000-15,000 years, indicating that the genetic input of people who may have brought agricultural technology into India from west and central Asia has been limited. (b) The diversity of genetic signatures found in India is high and their composition is complex. Many of these signatures have arisen within India and are of considerable antiquity, predating the arrival of Indo-Europeans and their subsequent demographic expansion within India. (c) We do not find evidence to support the hypothesis of a common genetic origin of caste and tribal groups in India. (d) A genetic signature (Haplogroup: R1a1-M17) found in high frequency in both Dravidian and Indo-European speaking caste

groups in India was found to have evolved about 12,000-14,000 years ago. This signature has its maximum frequency in western Eurasia.

These findings are entirely inconsistent with a model of recent gene flow from castes to tribes and a large genetic impact of the Indo-Europeans on the autochthonous gene pool of India. Instead, our overall inference is that an early Holocene expansion (about 10,000 years before present) in northwestern India (including the Indus Valley) contributed chromosomes carrying this genetic signature both to the Central Asian and South Asian tribes prior to the arrival of the Indo-Europeans. Finally, the study therefore, does not support that the high frequency of this signature in India, particularly among the Dravidian-speaking castes, reflects demic expansions of southwestern Asian Dravidian-speaking farmers and Central Asian Indo-European-speaking pastoralists.

Partha P. Majumder

Genomic studies on oral cancer

Polymorphisms at N-acetyl transferase 2 locus have been studied in genomic DNA of oral precancer (leukoplakia) and cancer patients and controls to know the risk of the diseases. Acetylation polymorphism did not modulate the risk of the diseases but *XRCC1* variant genotype at codon 399 increased the risk of leukoplakia among the slow acetylators (OR=5.1, 95%CI=1.4-19.7). *XRCC1* variant haplotypes in combination with slow acetylation increased the risk of both leukoplakia and cancer among mixed tobacco users. So, it is proposed that multiple risk genotypes on two loci increase the risk of cancer and precancer. Major allele at A12308G polymorphism on mitochondrial genome increased the risk cancer compared to controls and leukoplakia (OR=1.6, 95%CI=1.1-2.6; OR=2.1, 95%CI=1.3-3.5, respectively) in this study population. Major allele at A12308G polymorphism in combination with risk-genotype at *GSTM1* also increased the risk of cancer compared to controls and leukoplakia (OR=3.0, 95%CI=1.2-7.6; OR=4.8, 1.8-12.4, respectively). So, not only alone, polymorphism at mitochondrial genome also increased the risk of cancer in combination with risk-genotype at autosomal locus.

Bidyut Roy

Genomic Studies on cervical cancer

The status of the HPV16 E2 gene (disrupted or intact), nucleotide sequence alterations within intact E2 genes and LCR of HPV16 isolates in a group of CaCx cases (invasive squamous cell carcinomas, n= 81) and population controls (normal cervical scrapes, n= 27) was evaluated from Indian women. E2 disruption was detected by amplifying the entire E2 gene with single set of primers, while overlapping primers were used to determine if any particular region got selectively disrupted. Nucleotide variations in E2 and LCR were analyzed by PCR amplification followed by bi-directional sequencing. The associations between the viral factors and CaCx were analyzed using Fisher's exact or Chi-squared test and interpreted as OR (95% CI) and p-values. E2 disruption was significantly higher among the cases [3.21(1.01-10.18); p= 0.02], which was maximum in the region between nucleotides 3650-3872 (DNA binding region). The European (E) variant was found to be the prevalent subgroup (87.76% among cases and 96.30% among the controls) and the remaining samples were Asian American variants. Among the E subgroup, variation at position 7450 (T> C) within the E2 binding site-IV was found to be significantly higher among the E2 undisrupted cases (21/37; 56.76%), compared to controls (5/18; 27.78%) [3.41(1.01-11.55); p= 0.03]. Besides HPV16 E2 disruption, LCR 7450T >C variation within undisrupted E2 of E subgroup appears to be a major factor contributing to the risk of CaCx development in Indian women. Furthermore, polymorphisms in the E2 gene of HPV16 may not be significant for disease risk.

Shamila Sengupta

HPV Infection and cervical cancer in the Northeastern states of Manipur & Sikkim

This study has been completed. The objectives were: To determine the prevalence of HPV infection (overall and age-specific), among women from two northeastern states of India, (MN) and (SK).

Research Activities

Elucidating the role of life style, demographic and some host genetic factors (p53 and p21 gene polymorphisms as components of cell cycle regulatory pathway) in the etiology and natural history of high-risk, HPV related cervical neoplasia

Identifying biomarkers of disease development by analyzing the expression of a few cell cycle regulatory proteins that are known to interact with HPV oncoproteins.

HPV DNA in cervical scrape samples of married women from Manipur (n= 692) and Sikkim (n= 415) in Northeast India was determined and compared to that in West Bengal (n= 1112) in eastern India by PCR, using the MY09/11 consensus primers and type specific E6 primers corresponding to HPV18 and 18. HPV prevalence was lower in Manipur (7.4%) compared to Sikkim (12.5%), which closely followed West Bengal (12.9%). HPV18 was predominant in Manipur (2.0%), and strikingly lower (0.2%) in Sikkim and West Bengal (0.9%) while the reverse was true for HPV16. The proportion of HPV16/18 infections in Manipur (3.3%; 22/672) and Sikkim (3.89%; 14/359) were comparable and significantly lower than that in West Bengal (7.8%; 79/1007) among those having normal cervical cytology. Such prevalence was similar among all age groups in Manipur, increased with age in Sikkim and dropped with age in West Bengal ($P_{\text{trend}}=0.007$) similar to that reported earlier. At age ≤ 30 years, HPV16/18 prevalence in Manipur (3.3%) and Sikkim (2.5%) were comparable but were significantly lower ($p=0.05$ and 0.02 , respectively) in contrast to West Bengal (8.8%). Heterogeneity in overall and age-related HPV16/18 prevalence patterns was noted between these populations as in other worldwide studies. This further highlights the need of incorporating women of age ≤ 30 years for HPV testing to get the true profile of age-related prevalence. Moreover, the possibility of spread of HPV18 from Manipur to other parts of India cannot be ruled out. These findings are essential for developing optimized prevention strategies.

Host genetic susceptibility is known to influence cervical cancer (CaCx) development in HPV infected individuals. Viral oncoproteins E6 and E7 are known to deregulate a number of cell cycle regulatory genes in the process of cervical carcinogenesis. The objective of this case-control study was to identify whether variants of p53A72Pro and p21Ser31Arg and expression of the p16 protein were associated with increased risk for CaCx among women from Manipur. We genotyped by PCR and RFLP, 39 malignant samples (35 HPV16/18 positive) and 291 cytologically normal cervical cell scrapes (248 HPV negative and 42 HPV positive). Comparisons were made between HPV negative controls and HPV16/18 positive CaCx cases. P16 expression was determined by immunohistochemical method involving 16 cytologically normals (10 HPV negative and 6 HPV16/18 positive) and 24 CaCx cases (19 HPV16/18 positive). P21Arg31Ser variants and p53 Pro/Pro variant at codon 72 of p53 did not differ between cases and controls. Arg/Arg genotype prevalence was significantly lower among HPV16/18 positive CaCx ($OR_{\text{age-adjusted}}=0.34$; 95% CI: 0.07-0.84; $p=0.025$) compared to Pro/Pro and Pro/Arg together. Pro/Arg genotype was significantly associated with HPV16/18 positive CaCx ($OR_{\text{age-adjusted}}=2.26$; 95% CI: 1.01-5.04; $p=0.048$) compared to Pro/Pro and Arg/Arg together as well as in comparison to Arg/Arg genotype ($OR_{\text{age-adjusted}}=4.66$; 95% CI: 1.34-16.18; $p=0.015$) but not with Pro/Pro. P16 overexpression was found to be significantly associated with CaCx ($OR=11$; $p=0.013$) or HPV16/18 positive CaCx ($OR=18$; $p=0.019$) compared to HPV negative controls. The results suggest that heterozygosity at codon 72 of p53 is likely to enhance susceptibility to HPV16/18 positive CaCx among women of Manipur and that the proline allele could be responsible for the effect. Also, p16 overexpression by immunohistochemical detection could be a potential risk marker for development of HPV16/18 related CaCx.

Sharmila Sengupta

Statistical genomics

Some novel statistical methods have been developed for linkage and association analyses of complex genetic traits. These include:

developing a multivariate phenotype approach to dissect an end-point binary trait based on a linear regression strategy using identity-by-descent scores as the response variable and phenotypic observations as the explanatory variables.

Research Activities

developing a statistical equivalent of the binary Transmission Disequilibrium Test for quantitative traits.

developing a quantile-based regression method for association mapping based on population-based data.

Analyses were performed on:

EEG phenotypes in the ongoing Collaborative Study on the Genetics of Alcoholism Project funded by NIAAA.

Type 2 diabetes and related quantitative precursors.

Major psychoses phenotypes including bipolar disorder and schizophrenia.

Autism.

Social Sciences Division

During the period under consideration, the scientists in the Division have undertaken research, both theoretical and empirical, in diverse areas. Apart from research, the scientific workers of SSD have been involved in teaching various courses for B.Stat.(Hons.), M.Stat., ISEC (regular and specialization) and M.S. (Q.E) programmes. Several research fellows are currently working for their Ph.D. under supervision of members of the faculty of SSD. Various workshops and conferences have also been conducted during the period.

Economic Research Unit

Agricultural Economics

1. Tenancy contract

The study addressed the question of existence of share tenancy and fixed rent tenancy in Indian agriculture. Based on the NSS data, it suggested that among the factors considered, intensity of irrigation and land productivity are the most important ones to explain the changes in the extent and forms of tenancy in Indian agriculture during the recent decades.

2. Labour use efficiency

This study examined the question of substitutability and homogeneity of family and hired labour in agriculture of a less developed economy. Based on the cost of cultivation data, collected by Ministry of Agriculture, Government of India, the results of analysis showed that family and hired labour in Indian agriculture are weakly separable from other inputs, such as land and material inputs. These two labour inputs were found to be very close substitutes and equivalent in terms of efficiency.

3. Economic condition and nutritional status

A collaborative work was done with Biological Anthropology Unit to study how different sources of income and occupational groups of tribal households operate in maintaining their nutritional status. Based on an intensive village survey data among the tribal households in rural West Bengal during 2001, the study showed that owner cultivators were relatively better off in terms of their income and nutritional status as compared to tenant cultivators as well as landless labourers. Landless labourers, however, were found to be relatively less poor than the tenant cultivators. This was possible due to the availability of work throughout the year among the landless labourer households for the development of land-augmenting technology in the countryside of West Bengal.

Manabendu Chattopadhyay

Research Activities

Applied Development Economics

1. Transport Infrastructure and human well being

The existing level of understanding of the relationship between transport infrastructure and human well being in general, and poverty in particular, was found to be inadequate. Most of the evidence in the regard was anecdotal and not based on empirical results. The distributional socio-economic impact of road projects, especially the impact on the poor, was less known. An attempt was made to deal with the evaluation of socio-economic impact of four-laning of a stretch of a national highway on the rural population living in its proximity. The pure partial effect of NH2 was, by and large, observed to be positive and significant on important aspects of household living such as mobility and connectivity, poverty status, earning and employment opportunities, asset holding, access to education and health services and overall well-being.

Dipankar Coondoo

2. Poor in the North East

During recent decades the concept of human well-being has been shifted from economic to non-economic aspects of life as well. The condition of the poor was assessed, in terms of some selected economic and non-economic indicators of human lives, in the North East region, which is geographically quite different from rest of the country. The problem of poverty estimation in the region was also taken care of in the study and re-estimation of poor was, therefore, of an additional interest. Data from the National Sample Survey Organization for the latest sample round conducted during 1999 – 2000 were used for the study.

Saswati Das and Chaiti Shama Biswas

3. Rural development and dynamics of socio-economic change

Despite many positive changes in different sectors and regions of India, the existence of fundamental problems such as of rural backwardness, agricultural stagnation, abject poverty, poor education system and unemployment has been demonstrated by an empirical analysis. An urgent intervention in the face of both government failure and market failure was suggested for uplifting the rural people.

Buddhabeh Ghosh

4. World Inequality In social development Indicators

The Impact of globalization of market on inequality among the countries in quality of life has been explored. Quality of life does not connote only per capita income of the inhabitants; it also takes into account other aspects of quality of life of people of a country. An attempt was made to study inequality in different aspects of quality of life, such as life expectancy, female life expectancy, infant survival rate per thousand of population, adult literacy rate, female adult literacy rate, calorie intake per capita as percentage of requirement, physician per thousand of population, passenger cars per thousand of population, primary enrollment ratio, primary enrollment ratio of female child etc. The impacts of globalization on divergence / convergence in these different aspects of quality of life and the reasons behind such divergence/convergence have also been taken into account.

Krishna Mazumdar

Cooperative game theory

Power of an individual voter depends on the chance he has of being critical to the passage or defeat of a resolution. The Banzhaf Index is a normalized value of the number of coalitions in which the voter is in the critical position of making winning (losing) coalitions losing (winning). A new characterization of the index using four independent axioms from four different contributions to the area has been developed.

Coleman suggested two indices of voting power, power to prevent an action and power to initiate an action. Rigorous demonstration of the relationship between the two indices and their behavior with respect to different postulates of an index of voting power has been made.

An indicator of power, which has been shown to satisfy all the reasonable postulates for an index of voting power, was suggested for weighted majority games that arise in many practical situations. An axiomatic characterization of the new index has also been developed.

Satyajit R. Chakravarty and Sonali Roy

Demographic studies and gender studies

1. *Economic study of dowry*

A very common socioeconomic problem of Southeast Asia, the problem of dowry, was addressed. In this context, in a two period set up, the decision of a male head in a family regarding consumption and investment in human capital of his children was considered. From a social planner's perspective, having the objective of reducing overall dowry transfers, the effect of change in a few relevant parameters like population growth rate, employment opportunity and cost of education for women on these decisions was considered. Finally, the intergenerational effect through a rudimentary model of long run dynamics was explored.

Diganta Mukherjee

2. *Nutritional status of children*

Malnutrition among children is prevalent in almost all states in India. The extent and causes of malnutrition in two eastern Indian states with similar climates, namely West Bengal and Assam, were assessed using data from the National Family Health Survey 1998-99 (NFHS-2). The three indices of malnutrition taken for analysis were weight-for-height (WHZ), height-for-age (HAZ) and weight-for-age (WAZ). These were assumed to depend on birth order, preceding birth interval, parent's educational status, working status of the mother, mother's age at delivery of the children, source of drinking water, toilet facilities and standard of living of the household. Logistic regression was carried out separately for each of the three indices on the explanatory variables for both the states. Different sets of variables were obtained for two states and for three indicators to explain the levels of malnutrition. The importance of variables has not been found same in the two states.

3. *Height, weight and earnings among coal miners In India*

The earning/wage differentials by height among coalmine workers in India were analysed. Findings suggested that workers of above average height earned 9-17% more than their shorter counterparts and 6-13% more than average reference height. It was also found that long-term investments in health human capital might ensure increase of labour productivity and thereby earnings, particularly in underdeveloped economies.

4. *Measures of gender segregation*

The different measures of gender segregation so far proposed in the literature were reviewed. Gender Segregation is usually observed across occupations. The Measures of Segregations, strictly speaking, cannot be viewed as measures of inequality, but some special cases of these measures have the properties same as those of a measure of gender inequality.

Manoranjan Pal

Economics of Globalization

1. *Globalization, informalization and accounting*

Development strategy of India has been drastically changed from planning to market economy since 1991. Employment growth at the cost of output growth leading to productivity slow down and lack of overall competitiveness were seemed to be primarily responsible for increasing failure of the governments in establishing the welfare state. The interaction among the external and internal factors, responsible for India's economic development over the last decade, was analyzed. The evolving weaknesses, which were not considered in formulating current policies, were touched upon.

Research Activities

2. Infrastructure, regional income and globalization

An attempt was made to find out the role played by infrastructure facilities in economic development across South Asian countries over the last quarter century. The observations were found to be statistically very significant to warrant major changes in future regional policies in order to remove rising regional disparities in both infrastructure and income. The poverty removal policies for the poor being regionally concentrated in such diverse and heterogeneous regions of the world was expected to be successful even in the presence of market imperfections.

Buddhadeb Ghosh

Education Policy and Economics

1. Educating the poor in India

It might be stated that in the context of providing basic or primary education just pumping money in education would not be effective without creating productive occupational opportunities, social power for the poor through education by the Government.

Buddhadeb Ghosh

2. Parental altruism, ability and education

Relationship between investment in human capital and ability to acquire skill has been explored, in the backdrop of ability biased technological progress. As a departure from the existing literature, the parents investing in Children's human capital formation have been considered to be the major decision making unit rather than those acquiring skill themselves. It has been shown that under certain conditions forces operate to generate a unique critical level of ability for the economy as a whole, so that all individuals with higher ability level have been found to be skilled in every period and less able individuals remain unskilled period after period irrespective of the initial distribution of the skilled and unskilled parents over the ability space.

Chandana Ghosh

Environmental and Ecological Economics

1. Economics of urban waste management

Material goods and energy are involved in every economic activity like production, consumption, etc. creating wastes for disposal. The problem of management of such ever-increasing volume of material waste is now a matter of great concern for all urban areas and the task of decision-makers is to find out a proper management policy. Various hierarchical options for waste management to reduce the volume of wastes have been discussed here both from environmentalists' and economists' point of view. The economic instruments like taxation and subsidies have been found to be more efficient compared to regulatory measures for this purpose because of technological and financial constraints involved with this.

2. Economic of Pollution Control Regulations

Adoption of pollution abatement technology is almost mandatory now in the industrial sector to protect global environment. However, such abatement technologies have not been adopted on a wide scale by small-scale components of industrial sector in the third world countries, even after significant contribution to total pollution, because of high initial investment cost. Under these circumstances, an advantage in the competitive market was obtained by the early adopters for being able to calculate correctly the actual benefits of such investment keeping non-adopters out of market for lack of such knowledge. It has been found from a case study on secondary lead smelting industry that a positive net return has been received from the additional investment on control device. The result is instructive to the non-adopters.

Snigdha Chakrabarti

Financial Econometrics

1. Studying predictability and nonlinearity of Indian stock returns and foreign exchanging rate series

India is now considered to be the most important emerging market economy and indeed one of the major economies of the world. Consequently, its integration with the developed economies are now occurring to a great extent. In such an economic scenario, studying different aspects of major economic/financial variables of India should be both important and useful. The present study is concerned with predictability and nonlinearity of two most important time series viz., India's stock index and foreign exchange rate. The choice of these variables has been from consideration of the fact that in the past liberalization period, the roles of capital market and foreign exchange market are extremely important. In this study, we have taken into account major econometric issues like appropriate specification of the model, alternative volatility models and non-Gaussian distributional assumptions. Several nonlinear models like SETAR, STAR etc. have also been considered along with application modern econometric tools like predictive regression and co integration methods.

2. Mixture volatility model

In a given time series of any financial model, the nature of volatility may change over observations but typically it is not known which observations follow which kind(s) of volatility. Considering two volatility models, belonging to same class, and the concept of mixture ARCH model has been introduced and its properties derived. Estimation of the parameters of this model has also been carried out using an EM (expected likelihood maximization) algorithm. Simulation studies as well as a case study using NIFTY stock index series have been done to establish the superiority of the mixture ARCH model over the simple ARCH model.

Mhyananda Sarkar

3. Financial asset pricing model

Arbitrage Pricing Model (APM) assumes the residual to be normally distributed. This assumption was empirically checked in APM. An Arbitrage Pricing Model was built on returns from shares in National Stock Exchange (NSE). Four explanatory variables – Market Trend (Market Index), Sector Specific trend in the Market, (IT Index), Size of the company (Daily Turnover) and Location factor of the company (Index of Industrial Production) were identified. The normal distribution was compared with lognormal and exponential distribution in this context. The exponential distribution was observed to be better than lognormal and normal distributions. Univariate kernel smoothing method was also undertaken for univariate model based on returns dependent on IT Index. Exponential distribution was also observed to be better than Kernel smoothing and Normal distributions in Univariate model.

Dipanta Mukherjee

Human Poverty Index and Quality of Life Indicators

1. Human poverty Index

The human poverty index concentrates on deprivations in the living standard of a population in terms of failures in three basic dimensions of life, namely, decent living standard, educational attainment rate and life expectancy at birth. An axiomatic characterization of a family of global deprivation indices has been developed using an arbitrary number of dimensions of human life. By restricting attention to the three basic dimensions of life, a member of this family has become ordinally equivalent to the human poverty index. This breakdown has become quite important from policy point of view. An empirical illustration of the axiomatically characterized indices has been provided using cross-country data for the three basic dimensions and the anthropometric indicators like birth weight, height for age, weight for age and nourishment.

Satya R. Chakravarty and Amita Majumder

Research Activities

2. Quality of life index

The QOL index is a function of different attributes related to the basic needs fulfillment of the people of a country. A country tries to fulfill the basic needs of its people with fixed amount of resources available at a point of time. It is capable of fulfilling such needs in different combinations and it will try to maximize of the fulfilling the basic needs of the citizens. But every combination will not yield equal QOL to the people. At a point of time a country has a specific combination of attributes. QOL index of a country at a point of time is a function of this combination of attributes. The QOL index for a number of countries has been computed using a production function approach.

Krishna Mazumdar

Mechanism Design

1. Dominant strategy mechanism

A decision problem under incomplete information is first best implementable if there exists a mechanism that elicits private information and achieves efficiency with balanced transfers. The existence of queueing problems with one machine that are first best implementable under certain cost conditions has been demonstrated. The conditions on cost structure that leads to first best implementability in queueing problems with multiple machines have also been identified.

2. Optimal regulatory mechanism under incomplete information

A problem of regulating a monopolist having limited fund with unknown costs was considered. To obtain the optimal regulatory mechanism, following four properties were identified - (1) bunching at the top, i.e., the more efficient types producing the same quantity irrespective of their costs; (2) separability of less efficient types; (3) full bunching of types in the case of too limited fund and (4) having optimal output strictly lower than the second best output for any given type.

Manjushree Mitra

North-south model

An attempt was made to analyse the effect of the policy of tightening Intellectual Property Rights (IPR) in the South on the rate of innovation in the North and on the welfare in both North and South. This was done in a model otherwise identical to that of Helpman (1993) except in the concept of knowledge capital. Assuming that the South based imitated products do not contribute to the knowledge capital in the North, it was shown that the rate of innovation in the North was raised and the welfare of both North and South was improved for the tightening of IPR. These results are significantly different from those in Helpman (1993).

A dynamic North-South general equilibrium model of international product cycle was discussed. The qualitative effects of strengthening IPR on the balanced growth rate of the world economy were studied in two alternative cases: (i) imitation being direct from North to south; (ii) multinationalization being the channel of product transfer.

Manash R. Gupta and Debashis Nandi

Optimal travel path

An attempt was made to draw attention to the psychological factors of a traveler and discuss his choice of the optimal travel path from a number of alternative routes assuming that the psychological cost of a person traveling along a route is a function of the straight-line distance between his present position and destination. It was found that traveling along the relatively larger segment of the path was the first preference of the people to traverse under the 'rectangular' path hypothesis and a 'step' route was preferred in case of the 'triangular' path. The conditions explaining this behavior were also derived.

Tarun Karm

Price dynamics

An explanation as to why large sellers, on an average, get a better price for their produce than small sellers in potato markets in West Bengal was provided in terms of differential information across sellers of different sizes.

Abhirup Sarkar and Sandip Mitra

Technology - Economy linkage

In order to test economic development, different indices, representing technological capabilities of Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand with special emphasis on BIMST-EC, were estimated and the results were found to be statistically significant to warrant further disaggregated probe into the hypotheses set.

Buddhadab Ghosh

Time Series, Econometrics and Statistical Methods

1. Time series econometrics

The relationships amongst the major macroeconomic variables for the Indian economy were investigated in a multivariate time series framework. The objective was basically to see the efficiency of the available data to support standard macroeconomic relationships, like the consumption function, investment function, demand function, etc. considering sets of macroeconomic variables and using various time series techniques. In this sense, the study was completely *atheoretic*. Evidence of long run statistical relationships among the variables taken in groups was observed from the study. However, in some cases no co-integrating relationship was found to exist or the signs of the coefficients of estimated co-integrating vectors was found to be against conventional wisdom. Non-linearities in the co-integrating relationships were also allowed.

Dipankor Coondoo

2. Time series analysis of Indian macroeconomic data

Over the last two decades, there was substantial debate on the persistence of shocks, in terms of their transitory and permanent nature, known as Trend Stationary series (TS) and Difference Stationary series (DS), respectively. These two series were proved to be significant in the specification of the regression equation and testing competing economic theories. Though, there were a good number of studies to classify the macroeconomic aggregates, such as TS and DS, a need to reinvestigate these hypotheses afresh was aroused for relatively new developments of seasonal integration and presence of structural breaks in the macro variables. Some of these issues were examined by making use of the Indian data.

3. Panel unit root tests under cross-sectional dependence

Some alternative approaches were considered for testing the unit root hypothesis in panel data. First, a robust version of the Dickey-Fuller t-statistic under contemporaneous correlated errors was suggested and then the GLS t-statistic, based on the t-statistic of the transformed model, was considered. The asymptotic power of both tests against a sequence of local alternatives was also compared. A pre-whitening procedure yielding a test statistic with a standard normal limiting distribution was suggested to adjust for short-run serial correlation of the errors. The test procedure was further generalized to accommodate individual specific intercepts. Using Monte Carlo simulation method, the robust OLS t-statistic was found to be more appropriate with respect to size and power, but the GLS t-statistic might have been suffered from severe size distortions in small and moderate sample sizes, which could be improved using available bootstrap version of the test.

Samarjit Das

4. Quantification and modeling in ecological studies

To account for the variations in the size population of a particular species, which are mobile in nature like bird, for the effect of surroundings, quantification and modeling has now become prominent

Research Activities

features in ecological studies. To monitor the effects of intervention on an ecosystem, estimating abundance of particular species and bio-diversity of various species living together in a habitat becomes necessary. Traditional finite population sampling technique or capture-recapture technique suffers from various drawbacks for such mobile population. One method has been reviewed and appropriate modifications of this have been suggested.

Pulakesh Mall

5. *Modeling of buying behavior of Indian customers*

The 'Dirichlet model', which describes, for a stationary and un-segmented market, the purchase behavior of frequently bought branded consumer products, was tried to the Indian Data in a rigorous manner to explain the buying behavior of Indian customers. Validity of the model which assumes mixtures of distributions at different levels, namely negative binomial, multinomial, multivariate beta was examined for the Indian consumers.

6. *Building of Interactive linear models in survey sampling*

The problem of estimation of a finite population total where a set of investigators are employed to extract responses from a set of respondents and additionally, a set of supervisors are also employed to oversee the entire process and take corrective measures was considered. Notwithstanding the investigators 'bias and supervisors' bias, a mixed effects model has been developed with a study of the problem of unbiased estimation of finite population total after incorporating estimation of variance components.

7. *Handling of missing values through multiple imputation technique*

Issues of drawing of inferences of certain finite population parameter in the absence of a complete data set has been considered through multiple imputation technique of repetitive draws of the missing values from its posterior distribution.

8. *Estimation of the population parameters in the absence of its frame*

For some kind of populations, traditional finite population sampling technique is not feasible because of many reasons. One such reason is lack of information on the frame of population units, but a set of reference units with a well-defined linking rule connecting the population units and reference units may be available. With this information an estimation procedure has been developed for unbiased estimation of population size and of other population parameters, namely total mean.

Pulakesh Mall

Trade and Economics

1. *Trade and wage Inequality*

To give an account of trade induced symmetric increase in wage inequality; the factor price equalization (FPE) framework has not been followed in most of the trade models. In this context an attempt has been taken in this study to identify a plausible route through which trade might increase wage inequality in both the trading countries in a standard factor price equalization framework. A very simple two-sector model has been developed with one constant returns and another increasing returns to scale sectors. Assumption of identical preferences of the agents, given by a quasi-linear utility function, has been considered to capture (notionally) the division between basic and fancy goods. Considering two types of labour, skilled and unskilled, it was found that there has been a possibility of multiple equilibria in the model and under reasonable parameterization skill premium might increase in both the countries following trade.

Brati S. Chakrabarti and Abhinav Saha

2. *Effects of trade on foodgrains*

An attempt was taken to study the effects of opening up of international trade in foodgrains on industrial employment, balance of payments and the level of poverty in a less developed economy. It

Research Activities

was found that due to such trade there was a possibility of contraction of industrial employment along with deterioration of the balance of payments and an increase in poverty.

Abhinav Sarkar

Uncertainty and Choice

1. Choice under uncertainty

Economic agents' behaviour in uncertain situations, which is an important issue in all branches of economics, has been discussed lucidly, along with a rigorous proof of the main results in this area. In particular, the Expected Utility theorem – the canonical theorem on choice under uncertain had been proved by using some results in linear algebra. At the second stage applications of the theorem in various branches of economics, in particular, in portfolio analysis and stochastic growth theory had also been examined in detail.

Pulakesh Maiti

2. Cultural compatibility and Instability

Operational success of a venture firm is dependent essentially on the cultural compatibility of the partners. An attempt was made to draw attention to the country specific cultural characteristics and partner asymmetry, being the fundamental causes of joint venture instability and break down. Having asymmetric information about the type of one partner, a separating equilibrium was the more likely outcome of the other partner with high state nature of realization.

Tarun Kabiraj

The following research projects were undertaken during the period under consideration.

The valuation of Deepor Beel: an environmental economic approach

The objectives of this study are to assess the dependence of the stakeholders on Deepor Beel, a wetland in Assam, and to evaluate their perception about conservation of the Beel. Data collection was completed by February this year and on 17 March 2006 a paper on Hazard Management was presented using our field experience at an U G C sponsored seminar in Kolkata. Some experience was also explained about Deepor Beel by principal investigator in presenting his paper on valuing water bodies at Millenniums Institute of Environmental and Ecological management, Kolkata.

Kunal Chattopadhyay, Chiranjib Neogi and Pulakesh Maiti

Political economy of West Bengal

The objective of the study was to see whether there was a relationship between the political decisions of individuals and their economic environment. The unusual political stability in West Bengal coupled with moderate economic development since the inception of the left rule was the main concern. It was argued that this coexistence could not be fully explained either by land reforms or by agricultural growth. Informatization of the economy along with a strong party organization of the left was provided as an explanation to this coexistence. Data were collected from 2200 household spread over all the districts of West Bengal except Darjeeling. The processes of computerization of the data and preparation of report is in progress.

Abhinav Sarkar and Sandip Mitra

Study of some health economic issues in the North-East

The objective of the study was to study the relation between standard of living and health and Sanitation facilities in Meghalay and to review the health care system available to the tribal households in that place. The fieldwork is completed. Analysis of data and writing of report is under process.

Sandip Mitra, Manoranjan Pal and Biswanath Bhattacharyya

Research Activities

Poverty and household decisions – an exploration of possible Interdependence

The objective of the study was to identify the sets of poverty dimensions and decisions mutually reinforcing each other based on data collected through household survey conducted at two small clusters of villages in Assam – one in the neighbourhood of Guwahati and the other in the Kachar district. The field work in the villages in the neighbourhood of Guwahati and that in the Kachar district has been completed by March, 2006.

Dipankor Coondoo, Amita Majumder, Snigdha Chakrabarti, Sandip Mitra and Subhendu Chakrabarti

Agricultural growth In Assam since Independence

The objective of this study is to find out the pattern of agricultural growth in Assam since Independence and to formulate a growth model.

Unpublished time series data related to agriculture from various offices of the government of Assam located in Guwahati on the following aspects have been collected for Assam as whole and by districts of Assam: (1) Area and production and yield for total; rice, autumn rice, (2) Use of fertilizer in different crops, (3) Area under HYV rice and production, (4) Area affected by flood, (5) Rainfall.

Published data have been collected like NSPD for Assam, population of Assam. Using these data an exercise has been done to see the pattern of agricultural growth in Assam. A theoretical model has also been developed to explain this growth pattern. Data on irrigation, which are yet to be collected, was required for empirical verification of the model.

Manash R. Gupta and Chiranjit Hoog

Valuation of ecological services of Wetlands In India

The objective is to propose a common methodology for evaluation of ecological services of wetlands in India. During the period of four months, from 1st December 2005 to 31st March 2006, sample design has been framed, four different schedules, viz. household schedule, entrepreneur schedule, tourist schedule and expert schedule have been finalized. Three places, Sundarbans of West Bengal, Chilika Lake of Orissa and Deepor Beel of Assam have been selected for this study. Listing of households and entrepreneurs for the sample villages/mouzas have been completed for all three fields. Canvassing of the household schedules and the entrepreneur schedules have been completed in eight out of eighteen selected mouzas for Sundarbans. For Chilika canvassing of household schedules and entrepreneur schedules have been completed in twenty out of thirty two selected villages for Chilika. Some of the tourist schedules for each of Sundarbans and Chilika have been completed. A small number of expert schedules have been canvassed.

Krishna Mazumdar, Kunal Chattopadhyay, Subhendu Chakrabarti and Chaiti Shama Biswas

Economic Analysis Unit

The department was engaged in research in quantitative methods in economics and social sciences. Application of these methods to different problems in agriculture, industry and monetary economics is being actively pursued. Topics in agricultural economics, growth and inflation and estimating the effects of the economic reforms are of current interest. Research in inventory models under production smoothing hypotheses, variance-bound tests, intervention analysis, transfer function analysis and VAR and VECM models is being pursued by the faculty and research scholars of the unit.

N.S.S. Narayana

Linguistic Research Unit

From the period April 2005 to March 2006, the Linguistic Research Unit continues its programme of research in the areas of Quantitative Linguistics, Clinical Linguistics, Sociolinguistics, Neurolinguistics, and Corpus Linguistics and Language technology.

There are five main topics under which the Unit's research projects may be grouped, namely:

A. Methods in Quantitative Linguistics

a. Research design in applied linguistics, b. Text as a linguistic paradigm; c. Language Modeling

B. Sociolinguistics

a. Study of Language attitudes, b. Language planning in a plural society; c. Language and Mass Media

C. Clinical Linguistics

a. Habilitation of Speech disordered children

D. Neurolinguistics

a. Neurolinguistic perspectives in studying language disorders; (b) Development of Test Batteries

E. Corpus Linguistics and Language Technology

a. Defining rules for processing; (b) speech corpora in Indian languages; (c) electronic lexicon for Bengali.

Study of language attitudes

Work has been undertaken on questionnaire design in language attitudinal research. Some of the issues addressed are: Existence Questions: Does situation x exist? Is there such a thing as language unrest in a specific situation with reference to language x? Questions of Description or Classification: What is x like? What are its characteristics? What is the linguistic demography of x? Are there variations in x? Does classification of x give us a clue to the existing situation? Also the Unit has contributed to a number of articles on language planning in the Indian multilingual context. Issues range from minority languages, language movements, linguistic subalterity, language pedagogy and language for higher education.

Amitav Choudhry and Satarupa Dattamajumdar

Language and mass media

Research has been carried out both on micro and macro linguistic data, collected from news, entertainment and advertising media. This would eventually highlight and explain the tendency of a unique kind of hybrid language system, alarmingly alienated from the spontaneous natural language of human cognition, currently generated from the overwhelming input of the language of mass media.

Subhashree Ganguly and Satarupa Dattamajumdar

Clinical Linguistics

Study has been carried out on speech pathology with a view to enable a systemic approach to language habilitation in children with speech and neuro-linguistic disorders. Rehabilitation of children suffering from different kinds of disorders due to hearing impairment, neurological or autistic problems has been analysed, concentrating on the aspects of habilitation of different types and groups of speech disorders.

Data collection has been carried out extensively by visiting various clinical/educational and other social institutions, dealing with the habilitation of children with speech disorders. The developmental status of various speech sounds for language development has been studied as a foundation for understanding delayed milestones in language and related disorders, including the impact of hearing loss, psychosocial variables affecting language acquisition, disorders related to, congenital and acquired cognitive disabilities, etc. Taking cue from the contributions of different scholars and analyzing the data so far

Research Activities

collected, language identification and classification of disordered speech have been attempted (e.g. defect due to organic cause, rhythmic cause, psycho-genetic cause, etc.)

Different case studies have been done on different types of disordered speech like hearing impairment, cerebral palsy, autism, childhood schizophrenia, down syndrome, stuttering/ckuttering, etc. Different methodologies have been taken into consideration in order to develop an integrated habilitation programme in order to bring the individuals affected with such neuro-linguistic problems into the main stream of education. Language programming in educational setting has been made an integral part of the research programme.

Madhabi Indu and Satanupa Dattanajunda

Language technology

Analysing a large lexical database for defining linguistic rules for automatic processing of nouns, pronouns, adjectives, adverbs, postpositions, and other types of word found in Bengali corpus.

Developing an English-Bengali dictionary of idiomatic expressions, set phrases, and lexical collocations to be used as translation equivalents in Machine Translation.

Analysing various types of suffix parts used with Bengali adjectives to generate a suffix database to be used in automatic POS tagging of adjectives in corpus.

Accessing relevant websites and literature to design a model for generating speech corpora in Indian languages.

Designing a model for using information lexical items from Bengali corpora to develop electronic lexicon for Bengali.

Designing a model for using information derived from language corpora to be used in both first and second language education in Indian languages.

Working on a model for using information obtained from language corpora to develop a usage-based online electronic dictionary in Bengali.

Working on a model for using information collected from language corpora to develop a usage-based general grammar in Bengali.

Nisadi Sheikh Diah

Planning Unit, Delhi

Economic theory

A major research area has been the design of voting mechanisms with ambiguity and Choquet-rational players. The goal of this work is to characterize incentive-compatible random voting and allocation mechanisms.

Macroeconomics

The literature on growth and distribution is being extended to an open economy framework. Also on the research agenda is the issue of talent allocation and economic growth, and the impact of trade liberalization on product quality.

Financial development

Dynamic aspects of micro-finance have received attention. Schemes have been proposed (potentially applicable to India) that can solve the informational problems intrinsic in micro-finance. Empirical analyses of the Indian economy have encompassed a wide range of issues.

Environmental economics

Research Activities

A study of groundwater sales found high prices averaging 60 paise per cubic meter and a one-for-one responsiveness of water use to price suggesting that marginal cost pricing of electricity would substantially diminish groundwater over-extraction.

Commodity markets

Research showed that open economy policies and imports were critical in facilitating the evolution of a futures market in soya oil. A policy study on energy subsidies concluded that while the case for abolishing LPG subsidies was strong, eliminating kerosene subsidies would cause large welfare losses unless it is accompanied by rural electrification.

Other current research

Ongoing research has developed a theoretical model to be used to measure the long-term impact on families affected by HIV/AIDS. The other topics include examination of non-linear relationship between child labour and land wealth of households, benefits of road connectivity in rural India, measures of multidimensional inequality, and the costs of plant biotechnology regulation.

Sanghamitra Das, Satya P. Das, Chetan Ghate, Abhiroop Mukhopadhyay,
Bharat Ramaswami, Indip Ray, Probal Ray Chowdhury, Arunava Sen and E.Somanathan.

Population Studies Unit

During the past year research was carried out on the following topics:

Determination of child immunization

This was done for all states of India from NFHS1 and NFHS2 data and immunizational status between the two surveys was compared.

Swati Sadhu

Featuring nuptiality and demographic panorama

The study on nuptiality and demographic panorama of a few North Eastern States of India covers the broad areas of population dynamics, namely, fertility, mortality, nuptiality, migration and age distribution along with various socio-economic factors. The various sources of data are: Censuses, SRS, NSSO, NFHS (Phase-1 and 2) and other records. This topic is considered because the parameters mentioned above are still unexplored in the North Eastern States of India and accelerated population growth has been a major concern for them during the last five decades.

Anuj K. Saha

Morbidity pattern and health care practices of sex workers and their awareness about HIV/AIDS

The study confines to two red-light areas of North 24 Parganas. The aim of this study is to discuss the nature of illness of the sex workers. It investigates the diseases they are suffering from, type of health care facilities they are enjoying, use of condoms, why some workers are not taking any treatment and why some are self-medicating.

Swagata Gupta

Analysis of trends in mortality rates

Analysis of trends in age specific mortality rates by sex and mortality projection using the Time Series data from Sample Registration System (from 1970 to 2002). The objective of this study is to evaluate the trends of child and age-group wise mortality rates by sex and residence.

Subhas Barman

Research Activities

Correlates of child labour in India and major states

The objective of this study is to examine the causes of drop out from school of the children aged 6-4 years and their emergence as child labour. The study also examines the causes of child labour by sex and residence using National Family Health Survey Data I & II and Censuses 1991 and 2001 data.

Sobhas Barman

Temporal and spatial dimensions of under five mortality

The objective of the study is to find out the levels of components of under-five mortality with emphasis on the impact of National Health Programme and to examine the changes over time during the periods 1976-2004 in major states of India and India as a whole. It also tests for a causal relationship between changes and the health interventions. The entire study will help in understanding the factors determining the level of child mortality and the interventions to be required in the area of child health programme and also in other socio-economic developmental programmes at the state level to achieve the targeted goal set by the Government of India. Also based on the findings, suggestions may be given to improve the coverage of the health services among the deprived groups, improvement in quality of care and life in order to reduce child mortality in India.

Partha De

Construction of adjusted single year age data

Using some simple and new technique, attempts were made to construct adjusted single year age data for 2001 census of India and the states on the basis of raw 5-year grouped data of the census where adjusted single year data are not yet available. These data were important for researchers and policy makers for various purposes. Some works were already done. But more might continue later this year.

Barun K. Mukhopadhyay, Prasanta Kumar Hajumdar

Spatial dimensions of reproductive health status and services: an analysis of RHS/NFHS

The objective of this study was to analyse two rounds of NFHS data for assessing the reproductive health needs and the service utilisation.

Biswa Nath Bhattacharya

Psychological Research Unit

Team efficiency in work settings

The objective of the study is to identify important factors of team behaviour and teamwork, which affects team efficiency of different work teams. Here team efficiency is defined in terms of individual and team performance. Emphasis is given on to explore the variables, which are crucial for team performance in different work situations. The data for this study is being collected from the information and technology (IT) industry of eastern, western, northern and southern zones of India. Variables studied here are personality, self-efficacy, transactive memory system, collective efficacy, team climate, satisfaction, and team efficiency. Results indicate that team performance and individual performance are positively correlated with some of the input and process variables, which lead to efficiency of the teams.

Monica Sharma and Anjali Ghosh

A study on short-term memory assessment with successive decrease in stimulus presentation time using computer aided digit span test

In advertising, in criminal investigation specially related to vehicle accident, and in researches on information, education and communication, one major problem is to understand how much minimum time is required to retain a set of stimuli in the short-term memory store. No study is known to have been conducted on this issue. In this study, one computer aided digit span test was developed to determine short-term memory span and minimum duration for stores (MDS). Results revealed that

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age, extraversion and neuroticism moderate the relationship between short-term memory span and MDS.

Manjishtha Maltra and Debdulal Dutta Roy

Locus of control and social axioms

Individual's generalized expectancy concerning the determinants of rewards and punishments in their lives and their general belief about the social and physical environment, spiritual world and effort was studied in a group of college students. Findings indicate that students, who believe that there is little control over their own outcomes, take a negative view of human nature. On the other hand, students who are internals, reflected optimism towards challenges of life and believe that it can be resolved by human endeavour.

Anjali Ghosh

Infrastructure profiles of private and public schools

Purpose of the study was to explore infrastructure needs of different private and public schools of hill districts on Manipur. Data were collected from private and public school teachers of Senapati (least literate) and Churachandpur (more literate) districts in Manipur. Results noted significant difference among public schools of both districts in facilities of toilet, school exhibition, and school location. Private schools of both districts differed significantly in drinking water facilities, availability of school magazine and locations. Both private and public schools were significantly different in structure of school building, electricity, toilet, library, location of school from the main road and the nearest market. Findings are useful in understanding different patterns of organizational adaptation by the management of private and public schools.

Debdulal Dutta Roy

Assessing effectiveness of computerized exercises to develop cognitive skills

This is a collaborative project with Rutgers university of USA and with Step One Foundation for Child & Youth Welfare, a registered non – profit organization working in Kolkata. The objective of this research is to assess the validity of the Fast Forward tools (computer and internet based cognitive skill development tools) for school students in India. Step one in collaboration with St. Mary's school collected some psychological data from 28 boys (14 boys of day and 14 boys of orphanage section during pre- training period. Result revealed no significant difference in subtests of comprehensive test of phonological processing and in 2 subtests of the Test of Auditory discrimination between the boys of day and orphanage section.

Debdulal Dutta Roy

Analysis of the impact of workers education

The purpose of this study was to evaluate impact of Workers education on knowledge, attitude towards training and on different sets of organizational effectiveness criteria like Productivity, Wastage control, Quality control, Rate of accidents and Absenteeism. Results revealed significant impact of workers education program on the above across four major departments of a jute mill.

Anjali Ghosh, Debdulal Dutta Roy and Rumki Gupta

Sociological Research Unit

Forms of market and non-market discrimination: The case of rural dalit households

The study aimed at detailed 'micro-level research on forms of social and economic discrimination against rural Dalit hired manual workers in specific agrarian contexts. The focus was on agricultural labour households since the predominant occupation among Scheduled Castes households in rural

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areas has been wage labour. As primary village level data on wages, employment, access to formal and informal credit, education, housing, asset ownership and participation in the public distribution system were already collected from Haryana, Jharkhand, West Bengal and Tamil Nadu in course of previous projects, these data have now been disaggregated by caste. This has been followed by gathering additional information on forms of market and non-market discrimination for in-depth comprehensive analysis.

V.K. Ramachandran and Madhura Swaminathan

Techno-economic adaptation of the Mizos of hill forest ecology of Mizoram

The traditional pattern of villages in Mizoram, based on *Jhoom* cultivation, underwent a radical change following the implementation of the scheme of grouping of villages during the period from 1966 to 1970, coupled with permanent settlement and mechanization in agricultural production. Keeping the same ecological settings, the people of Mizoram have been trying to adapt to the emerging situation. The project sought to explore the process of techno-economic adaptation by the major tribes of Mizoram for understanding the need for developing measures of sustainable development.

Aniruddha Chakraborty and Shyamal Mukhopadhyay

Constraints of development of scheduled castes and other backward castes/ communities in rural areas

The empirical study intended to examine whether economic measures meant for upliftment of lower castes could make any worthwhile dent into the situation. The study, which has been conducted among rural communities predominantly of lower caste groups in a cluster of villages in Howrah district of West Bengal, sought to identify the various factors responsible for immobility of lower caste groups in socio-cultural and socio-economic hierarchy.

Tirthankar Ghosh, Kamalaksha Das, Sushmita Bharati, Suparna Som and Sonali Chakraborty

Role of social connections in coping with the changing situation: An exploratory study on the villagers of West Bengal

The study envisaged investigating whether villagers could find congenial support base in the network of interpersonal relations in the changing socio-economic situation of West Bengal. It also attempted to locate the role of 'social connections' in facilitating or constraining the scope of educational attainment and development of skills to get access to socio-economic opportunities.

Anur K. Chatterjee and Debashis Bhattacharya

Process of empowerment of women in rural areas: Case studies in two North-Eastern states.

The objective of the study was to understand the perception as well as the process of empowerment of women belonging to different social categories in rural societies in Meghalaya and Tripura. A major thrust of the empirical study was to compare the social situation in Meghalaya, where the elected Panchayati system (with one-third seats being reserved for women) has not yet been introduced, with that in Tripura where the elected Panchayati system, with the stipulated reservation for women, had already been implemented in accordance with the 73rd Amendment to the Indian Constitution.

Bhola Nath Ghosh

Empirical study on the labour-related problems of tea gardens in West Bengal

On the basis of primary and secondary data collected in course of field work, a project report has been completed suggesting a modality for a long-term optimum solution of the problem of casual workers in the tea plantation industry in West Bengal, taking into account land-labour ratio, additional new plantation, production, productivity, financial ability of the individual tea gardens, present employment pattern of permanent and temporary workers and other relevant factors.

Ata Dasgupta, Suraj Bandyopadhyay, Debashis Sengupta (Stat Math Unit) and Rabindranath Sinha

External evaluation of total literacy activities In the districts of West Tripura, Dhalai and North Tripura.

External evaluation of Total Literacy activities was conducted in districts of Tripura adhering to the norms stipulated by National Literacy Mission.

Atis Dasgupta, Shankar Dihidar (PSU), Dipankar Sen, Sushmita Bharati, Suparna Som and Sonali Chakraborty

A study of socio-economic impact of total literacy campaign in south Tripura District

An in-depth analysis has been undertaken on the basis of the field data collected in respect of socio-economic impact of Total Literacy Campaign in South Tripura district, with particular emphasis on the performance of the district in terms of 9-point development programme introduced by the Government of Tripura in the context of literacy programme implemented in the state.

Atis Dasgupta, Shankar Dihidar (PSU), Dipankar Sen, Sushmita Bharati, Suparna Som, Sonali Chakraborty, and Rabindranath Jana

Research Work In Giridih Branch

Follow-up studies have been undertaken on the five projects already carried out in Giridih Branch of SRU:

The first study sought to examine the responses of the urban and rural households to macro processes related to the decline of mica industry in Giridih town including the consequences on the gender issue; the second one envisaged an empirical study of marginalization of women workers in mica industry, analyzing the segregation of female workers in terms of their concentration in unskilled jobs as well as in the context of variation in their wages.

Molly Chattopadhyay and Sonali Chakraborty

The third study aimed at exploring potential power structure with emphasis on social network in the selected villages of Jharkhand; the objective of the fourth study was to investigate and compare the pattern of social relations under influence of factors like higher castes, feudal forces and Panchayati raj in some selected villages in Jharkhand and West Bengal.

Anil Choudhuri, Suraj Bandyopadhyay and Rabindranath Jana

The fifth study aimed at an empirical examination of the impact of economic reforms on rural credit markets in selected villages of Jharkhand.

V.K. Ramachandran

Statistical Quality Control and Operations Research Division

The Division now comprises nine units located at different places: Bangalore, Chennai, Coimbatore, Delhi, Hyderabad, Kolkata, Mumbai, Pune, and Vadodara and a Central SOC (CSQC) office located in the main campus at Baranagar. The CSQC office functions as an office of the elected Head of the Division and coordinates various activities of the Division.

The faculty of the Division is engaged in research, teaching, consultancy and training. Members of the Division at Kolkata take most of the teaching load for conducting the two year M.Tech (QROR) course at Kolkata and some members also teach courses for B.Stat (Hons.), M.Stat etc. The members of the respective units teach part-time certificate courses on SQC & OR, at Bangalore and Hyderabad. The faculty members of the Division also taught in various other academic programmes of ISI and other institutions during the year under review.

Supervising thesis, dissertation and project work by research scholars, M.Tech. (QROR) and M.Stat. students is also another aspect of the responsibilities of the Divisional members.

Research Activities

During the one-year period the Division organized 190 In-plant and 15 general training programmes tailor-made for the organisations' requirements. A large number of managers and other senior level executives and several operators and technicians have been trained on various topics of quality management. The division also expanded its activities beyond the national borders in providing its expertise to some countries in Asia like Iran and Nepal.

SQC & OR Unit, Bangalore

Integrating Six Sigma with other Initiatives

Integrating Six Sigma with other initiatives such as Lean, Project Management etc. is a challenging problem. The aim of this research is to develop an "Integrated Business Excellence Model" which may be used to effectively address the critical business issues of any organization. The model focuses on improvement of intrinsic capabilities of various processes using defect prevention, innovation in conjunction with appropriate metrics and associated measuring system. The model to be developed is generic in nature in that it can be applicable to Software, Manufacturing and Service sectors.

Mahesh Chinnagi

Semidefinite linear complementarity problem - a survey

In this survey SDLCP is introduced with some examples and applications and different properties of solutions to SDLCP is reviewed. Also various generalisations in the literature were considered and the state of art is reviewed. Open problems are also mentioned.

Research on predicting reliability for systems with deteriorating components is also being carried out.

G. Ravindran

Integrating different quality management systems

There are various International standards on Quality Management Systems (QMS), e.g., ISO 9001:2000, ISO/TS 16949 for automobile sector, ISO 14001 for environmental management system etc. Research is being carried out to look into the possibility of integrating the different quality management systems into one single QMS.

A K Chaudhuri, U H Acharya and Sanjit Ray

SQC & OR Unit, Chennai

A new procedure to construct failure models, indexed by two scales -age and usage is developed for the purpose of computing / estimating cost of two-dimensional warranty. An error in the existing method of warranty cost computation is pointed out and correction is proposed. Also a new methodology is formulated to determine optimal two-dimensional warranty that maximises customer utility.

D.K.Manna and Surajit Pal

SQC & OR Unit, Coimbatore

The members of the unit were engaged in providing training programmes and consultancy to various kinds of industries, particularly to textile industries. Issues concerning environment in petroleum refinery and textile were looked into and work on the same is being carried out.

SQC & OR Unit, Delhi

Generalized positive subdefinite (GPSBD) matrices

The class of generalized positive subdefinite (GPSBD) matrices is an interesting matrix class introduced by Crouzeix and Komlosi. Some properties of GPSBD matrices are obtained. It has been

shown that copositive GPSBD matrices are P_0 and a merely generalized positive subdefinite (MGPSBD) matrix with some additional conditions belongs to the class of row sufficient matrices. Further, it has been shown that for a subclass of GPSBD matrices, the solution set of a linear complementarity problem is same as the set of Karush-Kuhn-Tucker (KKT)-stationary points of the corresponding quadratic programming problem. A counter example is produced to show that a copositive GPSBD matrix need not be sufficient in general. Finally, it has also been shown that if a matrix A can be written as a sum of a copositive-plus MGPSBD matrix with an additional condition and a copositive matrix and if it satisfies a feasibility condition then Lemke's algorithm can solve $LCP(q, \bar{A})$. This further extends the applicability of Lemke's algorithm and a result of Evers.

S. K. Neogy and A.K. Das (Kolkata)

Almost type classes of matrices with Q -property

A new matrix class almost \bar{N} (a subclass of almost N_0 -matrices which are obtained as a limit of a sequence of almost N -matrices) was introduced and a sufficient condition for this class to hold Q -property is obtained. A counter example was produced to show that an almost \bar{N} matrix with Q -property need not be a R_0 -matrix. Further, another two new limiting matrix classes, namely \bar{N} of exact order 2, $\bar{E}(d)$ for a positive vector d are also introduced and sufficient conditions for these classes to satisfy Q -property were established. Pang's conjecture is shown true if E_0 is replaced by almost C_0 . A necessary and sufficient condition of an almost P_0 -matrix satisfying Q -property using game theory was also established.

S. K. Neogy and A.K. Das (Kolkata)

PPT based matrix classes

Various classes of matrices that are defined based on principal pivot transforms were studied and characterized. It was shown that matrices in these classes have nonnegative principal minors.

S. K. Neogy and A.K. Das (Kolkata)

Semidefinite linear complementarity problem

Some geometrical aspects of the semi-definite linear complementarity problem (SDLCP) can be viewed as a generalization of the well-known linear complementarity problem (LCP). SDLCP is a special case of a complementarity problem over a closed convex cone, where the cone considered is the closed convex cone of positive semi-definite matrices. It arises naturally in the unified formulation of a pair of primal-dual semi-definite programming problems. The notion of complementary cones in the semi-definite setting using the faces of the cone of positive semi-definite matrices is introduced. Unlike complementary cones induced by an LCP, semi-definite complementary cones need not be closed. The notion of a principal sub-transformation with respect to a face of the cone of positive semi-definite matrices is introduced. It was shown that for a self-adjoint linear transformation, strict copositivity is equivalent to strict semimonotonicity of each principal sub-transformation. Various other solution properties of SDLCP were interpreted and studied geometrically. The linear complementarity problem $LCP(M, q)$ over the second-order (Lorentz or ice-cream) cone was also studied. Some characterizations of the R_0 property were also obtained. The notion of nondegenerate linear transformation is introduced and the characterization of finiteness of the solution set of a linear complementarity problem over a closed convex cone in a finite dimensional real inner product space was obtained. Some geometrical properties of complementary cones were also explored.

S. R. Mohan and Madhur Malik

Research Activities

SQC & OR Unit, Hyderabad

Multivariate Process Control

Sensitivity of T^2 control chart to detect shifts in process mean level and in covariance structure of the process for both phase-I and phase-II operations are studied. It is observed that performance of a T^2 control chart for an even shift in process mean level is greatly influenced by the dimension (number of variables). For small dimensions (≤ 5) and for shifts of moderate to large magnitude in the process mean level T^2 control chart appears to be effective. However as the dimensionality increases beyond 10 the performance is getting reduced even for moderate to large shifts in the magnitude of the process mean. It was also observed that the T^2 control chart is sensitive for detecting changes in covariance structure interestingly. It is quite sensitive in detecting an increasing magnitude in covariance structure but insensitive in detecting reduction in magnitude of the same. Further, sensitivity is reduced with increase in dimensionality.

There has been some research on Markov Chain approximation method for computation of the ARL values for CUSUM and EWMA control schemes. We made a detailed study of the validity of the ARL values computed through Markov Chain approach for EWMA control scheme. It was noticed that there is a significant difference between the ARL values reported by earlier studies and those obtained through simulation of the same design parameters as suggested in the earlier studies. For smaller shifts the difference is quite large. Investigations into the possible reasons for the noted difference is being carried out.

P. Bhimasankaram and S.V.S.N. Murthy

Matrix Partial Orders

A motivation for Matrix Partial Orders defined through Generalized Inverses has been provided using matrix decompositions. Matrix Partial Orders of partitioned matrices has been studied in great detail. Inter-relationships among various Matrix Partial Orders have been developed. A connected account of Fisher-Cochran type theorems has been under preparation. Applications of Matrix Partial Order, parallel sums and shorted operators to Statistics have been explored.

P. Bhimasankaram and Saroj B. Maiti

SQC & OR Unit, Kolkata

Stopping time for software release

A new discrete Bayesian software reliability model for optimal decisions regarding 'when to stop software testing' was developed earlier. The model had an assumption that whenever a bug was detected it was fixed immediately without incurring any further cost. But, while working with an ISRO project, it was found that testing of software is carried out in phases. Bugs that are detected during a phase are fixed only after the phase is over but before going into the next phase. The model developed earlier is modified dropping the previous assumption and incorporating more realistic situation and a more generalized set up was developed. Further work on the model is being carried out.

A.K.Chakraborty

Quality Adjusted Lifetime (QAL)

We have developed a new method to estimate the distribution of quality adjusted lifetime (QAL) in a simple illness-death model. This method derives the theoretical expression for the distribution of QAL in terms of the sojourn time distributions and then substitutes the parameters in this expression by their estimates obtained by simple lifetime data analysis. Unlike the existing methods, this method can accommodate non-observability of some transition times and dependence between successive sojourn times.

Research Activities

The distribution of QAL has been derived in some illness-death models under different scenarios. Parameters are estimated by the maximum likelihood method. The EM algorithm has been used to obtain the estimates when some transition times are unobserved. We consider both parametric and non-parametric approaches. The distribution of QAL has also been derived under general progressive illness-death model, reversible illness-death model and other special models. The study on the properties of non-parametric estimate is in progress.

Biswabrala Pradhan, Anup Dewanji (ASU) and Debasis Sengupta (ASU)

Inference for the lifetime distribution based on Progressively Type-II Censoring data

The inference for the lifetime distribution of k-unit parallel system with exponential distribution as the component lifetime distribution based on progressively type-II censored data has been completed. The inference for other life distributions based on progressively Type-II censored data is in progress.

Biswabrala Pradhan

Some Implementation Issues of Six Sigma In Quality Management

Research work is being carried out to build on improvement methods that have been shown to be effective and to integrate the human and process elements of improvement through development of a model. The purpose of this integration is to make Six Sigma a holistic approach to enable it to produce proactive and reactive results by considering both breakthrough and incremental improvements.

The human elements take into account identifying and quantifying the parameters, which are important for customer satisfaction and employee satisfaction along with the aspects of leadership, teamwork and culture change.

The process elements of improvement consist of sequencing and linking statistical process control, design of experiments with tremendous emphasis on control of costs by identifying, quantifying and driving out costs of poor quality for achieving continual process improvement.

Anup Ranjan Mukhopadhyay

Inferential issues in reliability models

Monotonic aging can be modelled by different monotonic aging classes such as IFR, IFRA, DMRL, NBU, NBUE and their duals depending on whether the aging pattern is positive or negative. On the other hand non-monotonic aging is typically modeled using life distribution displaying a bath-tub shaped failure rate. Recently the Delayed Exponential Model and NWBUE life distribution have also been used. Another approach to model non-monotonic aging uses the notion of Mean residual Life function. Work involving the test of exponentiality against an NWBUE life distribution has been completed and published.

Md. Zalar Anis

Mathematical Programming and Game Theory

An attempt has been made to formulate the problem of solving the value vector and optimal stationary strategies for mixture of switching control and additive reward additive transitive stochastic games. A paper entitled *Complementarity property and a class of stochastic game with order field property* has been completed.

A.K. Das , A Gupta and S.K. Neogy (Delhi)

Mathematical programming and Neural Network

The linear fractional programming problem is an important class of mathematical programming problem. In fact there are algorithms to solve the linear fractional programming problem. We propose a solution procedure using the proposed dynamics based on neural network approach. A paper entitled *Neural network models for linear fractional programming problem* has been completed.

A.K. Das, P. Das and S.K. Neogy (Delhi)

Research Activities

Hybridization of Statistical Methods & Neural Network along with Mathematical Programming in the Field of Material Science

The main reason for the deficiency of progress in perfect prediction of mechanical properties of steels in terms of its composition and rolling parameters is that the property is dependent in a very complex way on a number of variables. It has been quite familiar to the scientists to adopt regression analysis in spite of a pre-chosen relationship to be called input-output relationship. Neural network analyses are the techniques, which are stated to be free from the ambiguities experienced in a regression analysis. It not only provides a representational framework for familiar statistical constructs, but along with statistical tools it has some treatments to some common problems of modeling and inference too.

Initial work on modeling of hot rolled steel plate classification using a statistical approach and neural-net systems will be published in Materials and Manufacturing Processes. Efficiency of neural-net vis-à-vis Mahalanobis-Taguchi system in classifying hot rolled steel product along with the effects of chemical composition of steel has been verified through three different studies, which are under review. An attempt on hybridization of ANN and desirability functions for process modeling has been made along with the development of two new transfer functions using the concept of desirability functions. The non-linearity in empirical modeling for the microstructure and mechanical properties of steel is being explored using statistical and neural network techniques from different directions, one of which is going to be published in IJPI journal.

Prasun Das

Analysis and Recognition of Control Chart Patterns

Control charts predominantly in the form of \bar{X} chart are recognised as one of the most important tools for SPC. However, the effectiveness of the control charts largely depends on the ability to detect various types of patterns that are commonly observed on these charts. The unnatural patterns are associated with impending problems having assignable causes requiring pre-emptive actions. Identification of various types of unnatural patterns can greatly narrow the set of possible causes that must be investigated and thus the diagnostic search can be reduced in length. Each type of pattern has its own geometric shape and various related features can represent this shape. Since extracted shape features represent the main characteristics of the patterns in a condensed form, use of features can facilitate efficient pattern recognition. In the present research work, various shape features of control chart patterns are defined and their usefulness is studied. Control chart pattern (CCP) recognizers are developed based on a best possible set of features using heuristic and neural network approaches and their relative performances have been studied extensively using simulated data. The proposed feature-based approach is found promising for automated process control. Work is in progress for developing more efficient pattern recognizers.

Susanta Kumar Gaur

SQC & OR Unit, Mumbai

The unit organized 17 in-plant and 4 general training programmes. Consultancy has been provided to seven corporate houses. The members of the unit also took part in some assignments at Iran.

SQC & OR UNIT, Pune

The members of the unit are working on applications of quality control and operations research in logistics. Also more statistically accurate overall sigma level assessment of an organization is being looked into. The unit organized several in-plant and one general training programmes. Consultancy has been provided to three large corporate houses.

Library, Documentation and Information Sciences Division

The Library, Documentation and Information Science Division comprises the Central Library at Kolkata, two major libraries at Delhi and Bangalore Centres, the Documentation Research and Training Centre

Research Activities

at Bangalore and the Prasanta Chandra Mahalanobis Memorial Museum and Archives at Kolkata. The division is perhaps the most important central facility and occupies a unique place in academic and research activities of the Institute. The fully computerized libraries at Kolkata, Delhi and Bangalore maintain excellent collections of books, current journals, rare books, government publications, data books, occasional papers, e-journals, on line databases and other documents/materials. The Institute offers a course leading to Associateship in Documentation and Information science, conducted by the Documentation Research and Training Centre at Bangalore.

Documentation, Research and Training Centre (DRTC), Bangalore

The main areas of research in which the different members of the DRTC Faculty were engaged during the period are given below:

The study of various methods of knowledge representation, such as, semantic nets, frames and predicate calculus etc.

The application of the modern scientific management techniques to the planning and management of information system, centers and services.

The study of Internet technology and its applications, digital library etc.

The development of bibliometric and scientometric measures for evaluating the use of library and information services and scientific output respectively.

The development of guidelines and software for library house keeping operations, such as, circulation control, service control, acquisition control etc.

Library, Kolkata

The Central Library of ISI is located in Kolkata with a network extending to other locations. Over the years, the Library has provided exhaustive information sources for academic and research activities of the Institute and has attained the distinction of being one of the richest libraries of the country, particularly in the field of Statistics, Mathematics, Economics, Computer Science and related disciplines. The Library also acts as the Eastern Regional Center Library of National Board for Higher Mathematics (NBHM) since 1989 for which it receives a grant from the NBHM, Department of Atomic Energy, Government of India.

It is an automated library having an excellent collection of books, journals, reports and large number of electronic journals and databases. The Library keeps open seven days a week throughout the year (except on national holidays) and the library staff aims to provide optimum services to the faculty members, scholars, students, visiting scientists and Institute Members as also to scholars from outside.

To achieve the goals of the Library, following activities were undertaken during the year under report –

Collection: The Library maintains an excellent collection of books, journals, reports, rare and special collection, government publications, data-books, theses and other documents/ materials in print and electronic formats. During the year under report the library accessioned 1197 books out of which 1150 were purchased from ISI budget and 47 from NBHM grant. 85 books were received on complimentary basis. It has added 66 theses in its collection. The Library also accessioned 1522 bound volumes of journals and subscribed to 478 scholarly journal titles in print. It maintains the publication exchange programme of 'Sankhya- the Indian Journal of Statistics' with national and international institutions/organizations through which the library has got 98 titles in this period. More than 50 journal titles were received as complimentary. The library received and processed more than 5000 loose issues of journals. It classified and catalogued 923 new books and filed 4970 computer printed catalogue cards. It also processed 250 titles on government reports/data-books etc. Beside this, the library has added a collection of 148 books, mainly in English and Bengali, on literature, humanities, travel, health and recreation in its statistical workers' circulating library totaling its collection