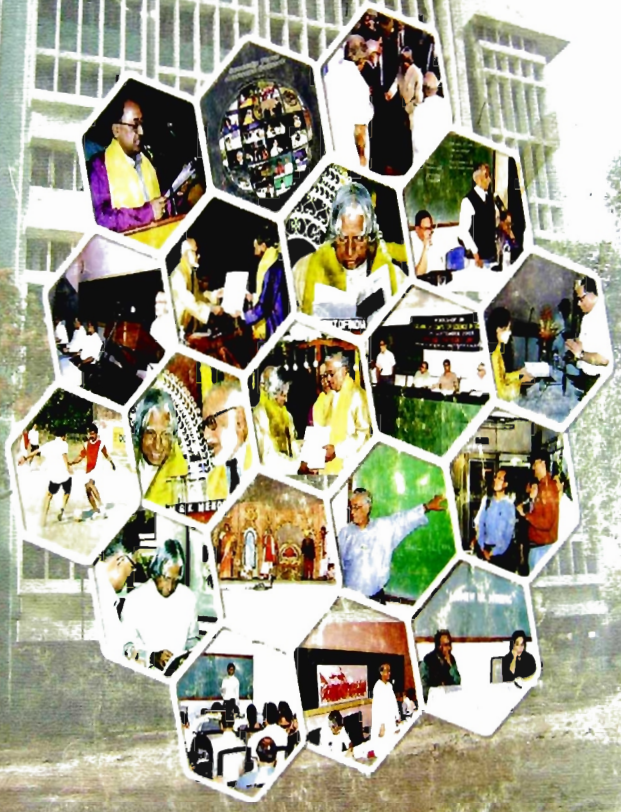
Annual Report

2003 - 2004



Indian Statistical Institute

ITITUTE, CHAIRMAN AND OTHER MEMBERS OF THE COUNCIL AS ON MARCH 31, 2004

President : Prof. M.G.K. Menon, FRS

2. Director Prof. K. B. Sinha, FNA

Representatives of Government of India

3. Dr A.K. Yogi, Deputy Director General (Training), Ministry of Statistics & Programme Implementation
4. Shri Gautam Basu, Additional Secretary & Financial Adviser, Ministry of Statistics & Programme Implementation.
5. Shri V. Rao, Aiyagari, Scientist "G" and Head, Department of Science and Technology, New Delhi
6. Dr. R.B. Barman, Executive Director, Dept. of Statistical Analysis & Computer Services, Reserve Bank of India, Mumbai

Scientists not employed in the Institute
Representative of ICSSR

7. Dr.Bhaskar Chatterjee, Member Secretary, Indian Council of Social Science Research, New Delhi

Representatives of INSA

8. Prof. K.R. Parthasarathy, Emeritus Scientist, Indian Statistical Institute, New Delhi
9. Dr. M. Vidyasagar, Executive Vice President, Tata Consultancy Services, Hyderabad
10. Prof. M.K. Chandrashekaran, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore
11. Prof. Sushanta Dattagupta, Director, S.N. Bose National Centre for Basic Sciences, Kolkata.

Representative of the Planning Commission

12. Dr. Pronab Sen, Adviser, Perspective Planning Division, Planning Commission, New Delhi

Representative of the University Grants Commission

13. Prof. B.K. Kale, Former Professor of Statistics, Pune University, Pune

Scientists co-opted by the council

14. Prof. Sujit Basu, Vice-Chancellor, Viswa Bharati University, Santiniketan
15. Prof. Probhat Pattanaik, Jawaharlal Nehru University, New Delhi

Elected representatives of members of the Institute not employed in the Institute

16. Prof. Deb Kumar Bose, Former Chairman, West Bengal Pollution Control Board, Kolkata.
17. Prof. Jogabrata Roy, Research Professor Emeritus, Indian Statistical Institute, Kolkata.
18. Prof. Shyam Maiti, Former Head, Plant Chemistry Unit, Indian Statistical Institute, Kolkata

Elected representatives of the employees of the Institute

19. Shri Ajay Kumar Ghosh, Representative of the Scientific Workers
20. Shri Sudev Gupta, Representative of the Non Scientific Workers

Officers of the Institute

21. Prof. Somesh Chandra Bagchi, Professor-in-Charge, Theoretical Statistics and Mathematics Division.
22. Prof. Anup Dewanji, Professor-in-Charge, Applied Statistics Division.
23. Prof. Atis Kr. Dasgupta, Professor-in-Charge, Social Sciences Division.
24. Prof. Dilip Saha, Professor-in-Charge, Physics and Earth Sciences Division
25. Prof. Monomjan Ghose, Professor-in-Charge, Biological Sciences Division.
26. Prof. Bhargab Bikram Bhattacharya, Professor-in-Charge, Computer and Communication Sciences Division
27. Shri B. Majumdar, Head, Statistical Quality Control and Operations Research Division.
28. Prof. Alok Dey, Head, Delhi Centre.
29. Prof. I.K. Ravichandra Rao, Head, Bangalore Centre.
30. Prof. Gour Mohan Saha, Dean of Studies.

Non-Member Secretary

Shri Debjyoti Bhattacharyya (Chief Administrative Officer)

INDIAN STATISTICAL INSTITUTE

Annual Report
April 2003 – March 2004

203 Barrackpore Trunk Road
Kolkata – 700108
(http://www.isical.ac.in)

Editorial Board

INDIAN STATISTICAL INSTITUTE
SEVENTY SECOND ANNUAL REPORT
April 2003 - March 2004

CONTENTS

Abbreviations of Unit names

Name of the Units	Abbreviations
Statistics and Mathematics Unit	(SMU)
Applied Statistics Unit	(ASU)
Advanced Computing and Microelectronics Unit	(ACMU)
Computer Vision and Pattern Recognition Unit	(CVPRU)
Electronics and Communicabon Sciences Unit	(ECSU)
Machine Intelligence Unit	(MIU)
Geological Studies Unit	(GSU)
Physics and Applied Mathematics Unit	(PAMU)
Agricultural Sciences Unit	(AGSU)
Anthropology and Human Genetics Unit	(AHGU)
Biochemistry Unit	(BIOCU)
Embryology Unit	(EMBU)
Economic Research Unit	(ERU)
Planning Unit	(PLU)
Population Studies Unit	(PSU)
Psychology Research Unit	(PSYRU)
Sociological Research Unit	(SRU)
Statistical Quality Control & Operations Research Unit	(SQC & OR)

A BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early nineteen twenties through the pioneering initiative of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological Survey of India, Dept. of Anthropology) and subsequent interactions with him led to the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists was picked up by him to start the Statistical Laboratory, in the Department of Physics, Presidency College, Calcutta, where he was a Professor.

In the early nineteen thirties, realising the necessity of a concerted effort for the advancement of theoretical and applied statistics in India, Professor Mahalanobis together with Professors P.N. Banerjea and N.R. Sen, both of Calcutta University, convened a meeting on 17 December 1931, to consider various steps to be undertaken for the establishment of an association for the advancement of Statistics in the country. It was unanimously resolved that the Indian Statistical Institute be established with Sir R.N. Mookerjee as President and Professor P.C. Mahalanobis as (Honorary) Secretary. The Indian Statistical Institute (ISI) was registered as a non-Government and non-profit distributing learned society on 28 April 1932, under the Societies' Registration Act No.XXI of 1860. The total expenditure in the first year was a meagre Rs.238.00 and the number of workers was only two or three. From such a modest beginning, the Institute grew, under the remarkable leadership of Professor Mahalanobis, into an all-India institution. Now the Institute has its headquarters in Kolkata and two Centres at Delhi and Bangalore and a branch at Giridih. In addition, it has a network of units of Statistical Quality Control and Operations Research (SQC-OR) Division at Baroda, Mumbai, Pune, Coimbatore, Chennai and Hyderabad.

From the very beginning, Professor Mahalanobis and his associates including Professors S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen and H.C. Sinha worked with untiring enthusiasm for the development of statistical theory and applications in different areas of natural and social sciences. Sankhya, the Indian Journal of Statistics, was started in 1933 with P.C. Mahalanobis as its Editor, and received instant international recognition which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale sample surveys. This led to a large number of high quality research publications and to the introduction of training activities offering short term courses in Statistics for officers in government departments and scientific institutions. The scientists of ISI, led by Professor Mahalanobis, helped in introducing the first post graduate degree course in Statistics in India at the Calcutta University in 1941.

In 1937, Professor Mahalanobis started sample surveys to estimate the area under jute crop in Bengal as an exploratory work, which later grew to a full-scale survey of the entire province in 1941. At the request of the Government of Bengal in 1944, a survey of economic and social conditions in Bengal was undertaken by the Institute to assess the cause and impact of the severe famine which had occurred in 1943. This survey yielded information of much social significance. Gradually, sample surveys of agricultural crops and other socio-economic surveys became some of the most important activities of the Institute and earned the Institute and Professor Mahalanobis international reputation. After independence, Professor Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet, Government of India, and in 1950, through his initiative, the National Sample Survey (NSS) was started for conducting socio-economic surveys on a continuing basis. This was the first ever attempt in India to have a data base for various developmental programmes and the five year plans. The ISI group on sample surveys served as the Technical Wing of the NSS from 1950 until 1972 when the latter was transferred to the Government of India.

The ISI also played a pioneering role in starting the Statistical Quality Control (SQC) movement in India by organising a visi t of Professor W.A. Shewhart, the father of SQC, to India in December 1947 and later by inviting other experts like Dr. W.E. Deming, Dr. Ellis R. Ott, Dr. H.C. Tippett and Dr. Genichi Taguchi. The SQC promotional work was gradually spread all over the industrial centres in India under a comprehensive programme covering education and training, applied research and consultancy services.

Research in Economics was greatly stimulated in the Institute when in 1954 Prime Minister Jawaharlal Nehru entrusted the preparation of the draft Second Five-Year Plan of the country to Professor Mahalanobis and the Institute. The "Draft" submitted by Professor Mahalanobis and the planning models formulated by him in that connection have since been regarded as major contributions to economic planning in India. Since then many economists of the Institute have worked in different centres of the Institute on various aspects of national planning and until 1970, were directly helping the Planning Commission in the preparation of the long term perspective plans for the country. Professor Mahalanobis's participation in 1946 in the annual scientific conferences of the Milbank Foundation led to the initiation of systematic studies in India on the growth of population. It is worth mentioning here that the application of statistical techniques in many areas in Social and Natural Sciences began in the Institute in the fifties. For example, the Institute developed new statistical methodologies for the analysis of directional geological data.

The Institute, since its inception, recognised the need for development and use of accurate and fast computing equipment for the processing and analysis of data. Professor Mahalanobis strongly believed that to be a good statistician one must also learn to compute and must therefore have the best computing aids. The Institute has lived up to this tradition from the very beginning. In 1953, a small analog computer was designed and built in the Institute. In 1956, the Institute acquired a HEC-2M machine from the U.K. which was the first digital computer in India, while in 1958 a digital computer URAL was received as a gift from U.S.S.R. Since 1956 till mid sixties, the Institute was *de facto* a national computer centre. In early sixties, the Institute, in collaboration with the Jadavpur University, undertook the des ign, development and fabrication of a fully transistorized digital computer, called ISIJU-1 which was commissioned in 1966 by Shri M.C. Chagla, the then Minister of Education, Government of India. The Institute has regularly upgraded its computing facilities and currently has a network of high-performance computers and a large bandwidth connection to the Internet.

As the Institute expanded, its re search, teaching, training and project activities earned national and international recognition. The outstanding contributions of the Institute to theoretical and applied statistical work culminated in Prime Minister Jawaharlal Nehru piloting the bill in the Parliament leading to the Indian Statistical Institute Act of 1959, which recognized the Institute as an "Institution of National Importance". By this act, the Institute was empowered to award degrees and diplomas, and the already existing teaching and training programmes were consolidated and expanded. Furthermore, the courses leading to the degrees of Bachelor of Statistics [B.Stat. (Honours)] and Master of Statistics (M.Stat.) as well as Ph.D. programmes were started from June 1960. Later on, courses leading to Master of Technology degrees in Computer Science and in Quality, Reliability and Operations Research were introduced. These programmes have been eminently successful in turning out well-trained students, many of whom have gone on to attain international reputation.

The Indian Statistical Institute Act of 1959 was amended by the Parliament in September 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. Following the amendment, a Master of Science course in Quantitative Economics and an undergraduate course, B. Math. (Honours) in Mathematics, have been added to the teaching and training programmes.

The role and importance of ISI in conducting teaching and training in Statistics has been appreciated by international bodies as well. In 1950, the International Statistical Institute in Netherlands, jointly with the Indian Statistical Institute, initiated the International Statistical Education Centre (ISEC) at Calcutta to impart training in Theoretical and Applied Statistics to participants selected from developing

countries. The centre is run by ISI jointly under the auspices of UNESCO, International Statistical Institute and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater impetus to research activities not only in Statistics and Mathematics but also in various branches of the natural and social sciences, which often provide live data for testing available statistical methods as also problems which need the development of new statistical methods. The Institute has always remained in the forefront of research in Statistics, Probability and Mathematics, both nationally and internationally. In Computer Science, new research areas were introduced in keeping with global developments. Selected areas in natural sciences began with small groups and saw some spectacular developments like the excavation of important dinosaur fossils from the Godavari Valley. This also justifies the adoption of "Unity in Diversity" as the motto of the Institute. The Memorandum of Association of ISI was amended first in 1976 and subsequently in 1995. The objectives of the Institute as laid down in the Memorandum of Association are :

(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, and

(iv) to undertake any other ancillary activities in fulfillment of the objectives (i), (ii) and (iii) above.

The Units of academic, scientific, administrative and service activities of the Institute were regrouped into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 1976.

From the early days, the Institute has been interacting with many internationally reputed scientists in different disciplines from all over the world. Some of these scientists have worked in the Institute for several months or even longer. Sir Ronald A. Fisher, a pioneer of modern statistics, was a regular visitor to the Institute and lent considerable support to its organization and development. Professor J.B.S. Haldane, a geneticist of international repute, was a member of the faculty for several years beginning from 1957. The celebrated mathematician, Norbert Wiener visited the Institute twice in 1954 and again in 1955-56 when he stayed for seven months and gave a course of 60 lectures. The other academic personalities whose visits influenced the development of the Institute include the statisticians Harold Hotelling, Frank Yates, Herman Wold, Edwin Harper (Jr.) and H. Cramer; the mathematicians A.N. Kolmogorov, Yu.V. Linnik, J.L. Doob and more recently Vaughan F.R. Jones; the experts in Statistical Quality Control Walter Shewhart and G. Taguchi; the Economists Simon Kuznets, Paul A. Baran, Joan Robinson, Jan Tinbergen, Nicholas Kaldor, R.M. Goodwin, David and Ruth Glass and J.K. Galbriath; the geologist Pamela Robinson; the biochemist N.W. Pirie and the linguist D. Kostic. All along the Institute has tried to live up to Ronald Fisher's dictum that Statistics is a "Key Technology" of the century, in view of its intimate relevance to all scientific endeavours which involve experimentation, measurement and inference from sample to aggregate.

For a long time the Institute has been organising international conferences and symposia, sometimes on focussed topics, sometimes on a broader field. Particular mention may be made of the 1974 Symposium on Probability and Statistics, the Golden Jubilee Conferences of 1981-82, the Haldane Centenary Conference of 1992, the Mahalanobis Centenary Conference of 1993, and the ISI-Bernoulli Society Conference of 1997, each of which, through the participation of a very large number of statisticians, probabilists and scientists of other disciplines from all parts of the world, were truly global meetings on the subjects.

Director's Report

It is with a profound sense of gratitude and of partial, yet genuine fulfillment that I write my penultimate report as Director of the Indian Statistical Institute. It has been a privilege and often a pleasure to serve at the helm of this great institution for the past nearly 4 years, and I owe a deep debt of gratitude to so many Faculty and Workers, Council Members, Visiting Scientists, professional colleagues and friends – who have helped make my tenure as Director an experience of a lifetime. The only regret I have is that I could not do more as a few of my conceived projects will not see the light of the day before I lay down charge.

Nearly three quarters of a century after its birth, the Institute remains largely true to the course set by the Founder, Professor P.C. Mahalanobis, to create a free society of scholars – free because mature persons, animated by intellectual purposes, must be left to pursue the goals of reaching the highest international standards. As a testimony to this, Professor Arup Bose of Theoretical Statistics & Mathematics Unit has received the C.R. Rao award in Statistics for the year 2002-2003, Professor Arunabha Sen of the Planning Unit, Delhi Centre has been elected a fellow of the prestigious Econometric Society and Professor B.B. Choudhury of Computer Vision and Pattern Recognition Unit, Kolkata was awarded the Jawaharlal Nehru Fellowship as well as the Homi Bhabha Award of the University Grants Commission. Amongst the younger faculty, Dr Debashish Goswami received the INSA medal for young scientists while Dr. U. Pal got the outstanding young researcher award from International Association of Pattern Recognition. The Institute is also proud to have been awarded a "Centre for Soft Computing Research : a National Facility" from the Department of Science & Technology under the leadership of Professor Sankar K. Pal of the Machine Intelligence Unit, Kolkata.

The first phase of constructions in the Headquarters at Kolkata has almost come to an end with the Academic Building Phase-I and the subway about to be handed over. With the commissioning of these two facilities, it is hoped that the faculty and other workers will strive towards their respective higher goals with new enthusiasm and vigour while the students and other residents in 205, B.T. Road will find the access to the main campus more convenient and more secure. The first phase of renovation work of Amrapali, which presently houses Professor P.C. Mahalanobis Memorial Museum and Archives, has been undertaken.

The next phase of construction envisages the construction of a modern substation (which is scheduled to begin shortly), the second building housing some academic units as well as a new auditorium, and possibly an additional floor to house a bank on top of the post office building.

It has taken a lot of effort to make these things happen in a restrictive regime, and I salute all my colleagues in the Engineering and Accounts Section, and other areas of administration. Last, but not the least, I must mention that without the untiring efforts and help of a few of my faculty colleagues, none of this would have been possible and I am eternally grateful to them.

30. 3. 2004

K.B. Sinha

Part I. Teaching & Training, Convocation, Research and Publications

1. TEACHING AND TRAINING

Degree and Other Courses

A brief account of teaching and training activities of the Teaching and Training Division during the academic session 2003-2004 is given below.

During the academic session 2003-2004 a total of 6853 candidates applied for admission and were called for written selection tests for various courses offered by the Institute, viz., B.Stat.(Hons.), B.Math (Hons.), M.Stat (S-stream), M.Math., Master of Science (M.S.) in Quantitative Economics, M.Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, Associateship in Documentation & Information Science, Research Fellowships in Statistics, Mathematics, Economics, Computer and Communication Sciences, Physics and Applied Mathematics, Sociology, Demography, Geology, Agriculture, Plant Chemistry, Embryology, Anthropology & Human Genetics. Admission tests were conducted at 24 different centres all over the country. A total of 4219 candidates finally appeared for admission tests and a total of 521 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests, interview and the academic record, 190 candidates were offered admission to various courses during the academic session under review.

The annual examinations for all the regular courses of 2002-2003 were held in May-June 2003. The 2003-2004 academic session commenced on 28th July 2003.

Two hundred ninety trainees in Engineering and Technology from various Universities (Asansol Engineering College; College of Engineering & Management, Kolaghat, Haldia Institute of Technology, B.N. College, Patna University; IIT Kanpur; Jadavpur University; Indian School of Mines, Dhanbad; Institute of Engineering & Management, Salt Lake, Calcutta, Regional Engineering College, Trichy; IIT Guwahati; Institute of Technology, Bhubaneswar), Indira Gandhi National Open University, Sikkim Manipal Institute of Technology, B.P. Poddar Institute of Management & Technology, College of Leather Technology (Govt. of W.B.), RCC Institute of Information & Technology, College of Ceramic Technology, Bengal Institute of Technology, Karpagan Arts & Science College, Regional Engineering College Durgapur, Netaji Subhash Engineering College, St. Thomas' College of Engineering & Technology, Dr. B.R. Ambedkar University, Agra, Electronics Research & Development Centre of India (Calcutta Unit), G.H. Raisoni College of Engineering, Tezpur University, Vidyasagar University, Murshidabad College of Engineering and Technology, Birbhum Institute of Engineering and Technology, Siliguri Institute of Technology, Birla Institute of Technology Birsa, MCKV Institute of Technology, Jorhat Engineering College, National Institute of Management Calcutta(NIMC), IIT Kharagpur and Kalpalaru Institute of Technology received two weeks/six weeks/two months/four months/six months M.C.A/Project training in different Computer Sciences Units of the Institute, viz., ECSU, CVPR Unit, CSSC, MIU, ACM Unit and ASU.

The number of candidates admitted to the different degree, diploma, Associateship courses and Junior Research Fellowship in 2003-2004 and the number of students who passed in the annual examinations and Ph.D degrees awarded in 2003 are given below.

Numbers of Students admitted to and passed different courses

Sl. No.	Course	Number of Students/JRF	
		Passed in the Annual Exam. in 2003	Enrolled in 2003-04
Degree			
01.	Bachelor of Statistics with Hons. (B.Stat (Hons.))		
	1st year	23	28
	2nd year	22	23
	3rd year	15	25
02.	Bachelor of Mathematics with Hons. (B.Math.(Hons.))		
	1st year	14	9
	2nd year	8	14
	3rd year	7	8
03.	Master of Mathematics (M.Math.)		
	1st year	-	9
	2nd year	-	-
04.	Master of Statistics (M.Stat.) (S-Stream)		
	1st year	33	37
	2nd year	24	29
05.	Master of Science in Quantitative Economics(M.S.(QE))		
	1st year	20	24
	2nd year	22	20
06.	M.Tech. in Computer Science		
	1st year	15	25
	2nd year	21	15
07	M.Tech. in Quality, Reliability & Operations research		
	1st year	12	14
	2nd year	12	12
08.	Ph. D. Degree awarded	15	29
Diploma			
09.	Junior Diploma in Statistics (JDS)	6	-
Associateship			
10.	Associateship in Documentation and Information Science (Bangalore)		
	1st year	6	5
	2nd year	8	6
	Grand Total	283	332

Ph.D. Degrees Awarded

A) Ph.D. Degree awarded by the Institute :

Sl. No.	Name of the Fellow	Title of the Thesis	Name of the Supervisor(s)
1.	Meeta Keswani Mehra	Theoretical Issues in The Economics of International Trade and Environment	Prof. Satya P. Das Planning Unit, ISI Delhi
2.	Pabitra Mitra	Certain Pattern Recognition Tasks for Data Mining Problems	Prof. Sankar K. Pal MIU, ISI
3.	Samarjit Das	Some Issues on Time Varying Risk Premium in ARCH-M Model	Prof. Nityananda Sarkar ERU, ISI
4.	Rajlakshmi Mallik	Aspects of Financial Dualism in Less Developed Countries	Prof. Abhirup Sarkar ERU, ISI
5.	Sangeeta Bansal	Environmental Regulation in the Presence of Environmentally Conscious Consumers	Prof. Subhashis Gangopadhyay Planning Unit, ISI Delhi
6.	Anirban Kar	Essays on Minimum Cost Spanning Tree Games	Prof. Bhaskar Dutta Planning Unit, ISI Delhi
7.	Sanghamitra Pal	Contributions to Emerging Techniques in Survey Sampling	Prof. Arijit Chaudhuri ASU, ISI
8.	Dipjyoti Majumdar	Essays in Social Choice Theory	Prof. Arunava Sen Planning Unit, ISI Delhi
9.	Susanta Mukhopadhyay	Morphological Tower: A Tool for Multi-Scale Image Processing	Prof. Bhabatosh Chanda ECSU, ISI
10.	Arijit Bishnu	Combinatorial Techniques for Digital Image Characterization and Retrieval: Algorithms, Architectures and Applications	Prof. Bhargab B. Bhattacharya ACMU, ISI
11.	Mausumi Acharyya	On Textured Image Analysis using Wavelets	Prof. Malay. K. Kundu MIU, ISI
12.	Anita Majumdar	Deformation Theory of Dialgebras	Prof. Goutam Mukherjee Stat-Math, ISI
13.	Kausik Kumar Majumdar	Some Studies on Uncertainty Management in Dynamical Systems using Fuzzy Techniques with Applications	Prof. Dwijesh Dutta Majumder ECSU, ISI
14.	Amab Kumar Laha	Slippage and Change Point Problems with Directional Data	Prof. Ashis Sen Gupta ASU, ISI
15.	Analabha Basu	Some Statistical Contributions to the Analysis of Human Genome Diversity and Evolution.	Prof. Partha P. Majumder AHGU, ISI

B) Ph. D. Degree awarded by Academic Bodies other than ISI for work done in ISI.

Sl. No.	Name of the Fellow	Title of the Thesis	University	Name of the Supervisor(s)
1.	Sujit Adhikary	Maize Based Intercropping SystemsWith Legumes and Their Residual Effect on Wheat and Barley Under Rainfed Condition of Chotanagpur Plateau Region.	Visva Bharati	Prof D K Bagchi, ISI & Prof. T. K. Chakraborty VBU
2.	Prabir Kumar Ghosal	Studies On The Direct and Residual Effect of Different Sources of Phosphatic Fertilizers On Latentic Rice Soil In Chotanagpur Plateau Region.	Visva Bharati	Prof T. K. Chakraborty V.B.U & Prof Buddhadeb Bhattacharyya CU
3.	Tapan Kumar Sasmal	Agricultural Practices in Usri Watershed Area Of Bihar Plateau- A Study in Different Agro-Ecosystem	Visva Bharati	Prof. D. K. Bagchi, ISI & Prof D. Dasgupta, BCKV
4.	Basudeb Datta	Sedimentological Evolution of The Protenozoic Siliciclastic Succession in the South- Central Part of Chattisgarh Central India.	Jadavpur	Dr. S. N. Sarkar, ISI
5.	Rohini Ghosh	Maternal and Child Health in two Ethnic Groups Inhabiting a Peri-urban Habitat: A Micro-level Study.	Calcutta	Dr. P. Bharati, ISI
6.	Bhaskar De	Scaling Ideas in High Energy Physics : a Status Report and an Impact Analysis.	Jadavpur	Prof. Subrata Bhattacharyya, ISI

INTERNATIONAL STATISTICAL EDUCATION CENTRE (ISEC)

The Centre was established in 1950 and is operated jointly by the International Statistical Institute, Netherlands and the Indian Statistical Institute, under the auspices of UNESCO and the Government of India. It functions under a joint Board of Directors. The Directors represent International Statistical Institute, Indian Statistical Institute and the Government of India. Prof. P.C. Mahalanobis was the Chairman of the Board of Directors since the inception of the Centre in 1950 until his death in 1972. Since then National Professor C.R. Rao, FRS, has been the Chairman of the Board.

The Centre provides training in theoretical and applied statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia, the Far-East and the Commonwealth countries in Africa. Major training programme of the centre is a 10-month regular course in Statistics leading to Statistical Training Diploma. In addition, special courses of varying duration are also organized. Facilities also exist for research work and advanced studies by senior statisticians from abroad.

The announcement of the 57th term ISEC Regular Course was issued and prospectus and application forms were distributed by the Centre at Kolkata on behalf of the Permanent Office of the International Statistical Institute at Voorburg, Netherlands. A number of prospectus and application forms were also distributed through Government of India. The governments of different countries were invited to nominate suitable candidates for training at the Centre. The Centre also requested the Indian Missions in different countries to extend their co-operation in receiving and forwarding applications both for admission and for fellowship.

A total of 15 candidates had been offered admission to the 57th term of the Regular Course of this Centre. Of the 15 candidates, 11 joined the course. 9 trainees were supported by fellowship awarded by Government of India under the Technical Co-operation Scheme of the Colombo Plan (TCS of Colombo Plan) and the remaining 2 trainees received support from Special Commonwealth African Assistance Plan (SCAAP).

All the trainees in the Regular Course have successfully completed the course and have been recommended for the award of Statistical Training Diploma except one trainee from Sri Lanka who had discontinued the course on health ground. While most of the evaluation was through written tests, the evaluation of the specialization training was partly carried out through project work and assignments.

The trainees were provided with computer facilities with internet connections in the ISEC PC room and in the ISEC hostel. They had access to ISI library. The trainees participated in different programmes in ISI and outside. The ISEC hostel has recently been renovated.

The Regular Course of the fifty seventh term started on 1 June 2003. English is the medium of instruction at the Centre. The training included lectures, laboratory work, project work and assignments. The first four months at Kolkata were devoted to general statistical training including training in mathematics, electronic data processing, probability theory, descriptive statistics, sample survey techniques, statistical methods and economic statistics. These courses were compulsory for all students. Further training for six weeks in Official Statistics was conducted by the Central Statistical Organization, Government of India, New Delhi, during September 29, 2003 to November 01, 2003. This was followed by eight-week training at Kolkata in general statistical methods for optional subjects during November 04, 2003 to January 03, 2004. In this phase the trainees pursued more vigorously some of the courses (at least four) studied by them during the first four months. Finally, from middle of January to March 2004 the trainees specialized in particular fields of applied statistics like demography, data processing, large-scale sample surveys and Economic Planning. All these Specialization Courses expect Economic Planning were held in Kolkata. The Specialization Course on Economic Planning was held in Bangalore in the Economic Analysis Unit of Indian Statistical Institute.

The teachers at Kolkata were mostly drawn from the various units of the Indian Statistical Institute while Statistical Officers of the Govt. of India took part in the teaching programme of the six-week course in Official Statistics organized by the Department of Statistics, Government of India, New Delhi. The teachers of Economic Analysis Unit at Bangalore Centre of ISI taught the specialization course on Economic Planning. Besides, Professor Dipankar Coondoo, ERU, Indian Statistical Institute, Kolkata was invited to give special lectures.

The valedictory ceremony for the ISEC Regular Course was held on 26 March 2004. Professor K B Sinha, Director, Indian Statistical Institute presided over the meeting and Professor Asis Kumar Banerjee, Vice Chancellor, University of Calcutta was the Chief Guest and delivered the valedictory address.

Professional Examinations in Statistics

The Indian Statistical Institute holds Professional Examinations in Statistics in the theory and practice of analysis of statistical data, for the external candidates on the basis of some model guidance for the award of the following diplomas :

1. Junior Diploma in Statistics
2. Senior Diploma in Statistics

These examinations are separate from and independent of the examinations held for the award of degrees, diplomas and certificates on the basis of training given by the Institute.

The Government of India recognizes the Junior Diploma in Statistics as equivalent to Bachelor's degree in Statistics and the Senior Diploma in Statistics as equivalent to a Master's degree in Statistics.

These examinations are held now-a-days twice in a year usually in or about the months of April-May and November/December at different cities in India (Bangalore, Chennai, Delhi, Hyderabad, Kolkata, and Mumbai).

The total number of candidates registered, appeared and passed for January 2004 term and May 2004 term are given below :

EXAMINATIONS	Registered		Appeared	Passed
	January 2004	May 2004	January 2004	January 2004
Junior Diploma in Statistics	19	10	09	04
Senior Diploma in Statistics	09	04	05	04

The cumulative total number of candidates who have qualified for the award of the Diplomas in the Professional Examinations in Statistics including the result of January, 2004 term is 300.

2. Convocation

The 38th Convocation of the Indian Statistical Institute was held on 27th February, 2004, at 3:15 PM. It started with National Anthem by ISI Club followed by welcome address by Prof. M.G.K. Menon, President, ISI, and report/speaches by Prof. K.B. Sinha, Drector, ISI, Shri Satyabrata Mukherjee, Union Minister of State and Shri Viren J. Shah, Governor of West Bengal. Honorary D.Sc. degree was awarded to Prof. S.R.S. Varadhan, USA, by the chief guest Dr. A.P.J. Abdul Kalam, Hon'ble President of India. This was followed by Convocation address by Dr. Kalam. The first phase of the Convocation was closed after a vote of thanks by Prof. G.M. Saha and National Anthem by ISI Club. After the departure of Hon'ble President of India, the remaining part of the Convocation started with Vedic Hymn by ISI Club. Then, the degrees and diplomas were awarded to students by Prof. M.G.K. Menon, President, ISI. The Convocation was closed by Prof. M.G.K. Menon, after a vote of thanks by Prof. G.M. Saha.

The Numbers of candidates who obtained degrees/diplomas in the Thirty Eighth Convocation of the Institute, is given below.

	Degree/Diploma	Number of Candidates
1.	Doctor of Philosophy (Ph.D.)	15
2.	Master of Technology (M.Tech.) in Computer Science	21
3.	Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	12
4.	Master of Statistics (M.Stat.)	24
5.	Master of Science (M.S.) in Quantitative Economics	22
6.	(a) Bachelor of Statistics (Honours) (B.Stat. (Hons.))	14
	(b) Bachelor of Statistics (B. Stat.)	1
7.	(a) Bachelor of Mathematics (Honours) (B.Math. (Hons.))	5
	(b) Bachelor of Mathematics (B. Math.)	2
8.	Associateship in Documentation and Information Science, Bangalore	8
9.	Professional Examinations in Statistics :	
	Junior Diploma in Statistics	6
	Total	130

Awards

1. Mahalanobis International Symposium on Statistics Prize to the most outstanding M.Stat. student of the Institute :

   Bhamidi Sreekalyani Shankar

2. Indian Statistical Institute Alumni Association Mrs. M. R. Iyer Memorial Medals to the outstanding students of the Institute :

B.Stat. (Hons.)	: Arijit Chakrabarty
M.Stat.	: Bhamidi Sreekalyani Shankar
M.S. (QE)	: Sambuddha Ghosh
M.Tech. (QROR)	: Sarbari Ghosh

3. Indian Statistical Institute Alumni Association Rashi Ray Memorial Medal for outstanding performance in M.Tech. in Computer Science :

   Subhamoy Chakraborty

4. Haldane Memorial Prize: 2003-2004 for research work done in Medical Statistics, Biostatistics:

   Sourabh Ghosh

5. Raja Rao memorial Prize : 2003-2004 for research work done in the areas Survey Methodolog/Econometrics/Demography :

   Ravendra Kumar Sharma (Institute of Economic Growth, Delhi)

3. RESEARCH AND OTHER SCIENTIFIC 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, Physical and Earth Sciences, Statistical Quality Control and Operations Research and Library, Documentation 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 organisations. 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. For academic and administrative convenience, a number of Divisions (each division having one or more units) have been formed which are listed below :

1) Theoretical Statistics and Mathematics

2) Applied Statistics

3) Computer and Communication Sciences

4) Physics and Earth Sciences

5) Biological Sciences

6) Social Sciences

7) Statistical Quality Control and Operations Research

8) Library, Documentation and Information Sciences

In addition, there is a well equipped Computer and Statistical Services Centre (CSSC) which manages the central computing system, e-mail and internet facilities and provides computing and statistical services to researchers.

There is a campus-wide computer network in the Institute's headquarters at Kolkata and researchers, students, scholars etc. can access the computing facilities from any terminal. As a part of computer networking, all faculty members have been provided with individual PCs, connected to the network, in their offices. Delhi and Bangalore Centres of the Institute also have similar facilities.

A brief account of the research activities in different divisions and units during the year is given below.

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. Side by side with 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 members of the faculty are also associated with the administration of the Mathematics Olympiad Project of the NBHM at the regional and national levels.

Stat-Math Unit, Kolkata

Research Activities

The Unit is engaged in research in many areas of Statistics, Probability, Mathematics and Computer Science. Some details of research activities of the faculty are given below:

We have studied the relation between the MIP and a farthest point phenomenon. It was known that in a reflexive space the MIP is equivalent to the following: every closed bounded convex set is the closed convex hull of its farthest points. We extended this result to characterize when every member of a so-called "compatible" family of closed bounded convex sets is remotely generated. In particular, we show that if X is strictly convex, then every (weakly) compact convex set in X is remotely generated if and only if every such set is admissible; and if X has the Radon-Nikodym Property (RNP), then similar result holds for w*-compact convex sets in X^*. We also studied a notion of strongly farthest points and characterized strictly convex and locally uniformly convex spaces. We also studied the farthest distance map r_K of a closed bounded set K and its subdifferential ∂r_K.

We introduce a notion of subspaces called nicely proximinal subspaces and characterize them. We give a characterization for spaces having RNP using nicely proximinal subspaces. We show that the metric projections onto nicely proximinal subspaces are continuous. We also prove stability and transitivity results in some particular cases.

We derive the proximal normal formula for almost proximinal sets in a smooth and locally uniformly convex Banach space. Our technique leads us to show the generic Frechet smoothness of the distance function in the case the norm is Frechet smooth and we derive a necessary and sufficient condition for the convexity of Chebyshev set in Banach space X with norms on X and X^* locally uniformly convex.

Pradipta Bandyopadhyay

Some general results on the rate of convergence of the empirical spectral distributions of large dimensional random matrices were obtained (jointly with Sourav Chatterjee, Stanford University).

An invariance result was obtained for random Toeplitz matrices (jointly with Sourav Chatterjee, Stanford University and Sreela Gangopadhyay).

Some progress has been made in the study of limits of sums of ranked set observations (jointly with Anish Sarkar, ISI, Delhi).

Work on generalised bootstrap (jointly with Snigdhansu Chatterjee, University of Minnesota) that demonstrates its theoretical validity and its application in a wide variety of estimating equations was finalised.

Arup Bose

Some scale-space type versions of kernel and nearest neighbor classifiers were developed that were found to have very impressive performance on several benchmark high dimensional data well known in machine learning literature. These new classifiers have performed much better than classifiers based on a single optimum value of the bandwidth parameter in the case of kernel discriminant analysis and the neighborhood parameter in the case of nearest neighbor discriminant analysis. A multi-scale visualization device that effectively supplements the aggregated final classification has been developed and successfully implemented on several benchmark data sets.

Probal Chaudhuri

Investigations were done on the existence of a connection on a principal $O(n)$-bundle with prescribed first Pontrjagin form. More specifically, if P is a principal $O(n)$ bundle over a C infinity manifold M of dimension m, then we showed that every differential 4-form representing the first Pontrjagin class of P

is the Pontrjagin form of some connection on P provided n is greater than or equal to $5m+4+4(((m+1)$ *choose* $4))$.

Mahuya Datta

It was shown that dialgebra Cohomology of a dialgebra A with Coefficients in itself, admits G-algebra structure which relates deformation theory of dialgebras.

G. Mukherjee and Anita Majumdar

A homotopy Garstenhaber structure on the Bredon-Illman Complex defining cohomology of a space with a topological group action was obtained.

G. Mukherjee and Neeta Pandey

Study of quasi-isometry group of f.g. group continued. Characterization of groups Γ for which the natural homomorphism Aut $(\Gamma) \to$ QI (Γ) is a monomorphism was obtained.

A.C. Naolekar and P. Sankaran

We have addressed the issue of use of improper priors, necessary for integrating out nuisance parameters under both the null and alternative hypotheses while testing a composite hypothesis by SPRT. If the prior is improper, Wald inequalities will not hold in general. We have discovered sufficient conditions and have then verified that the usual sequential $|\ t\ |$--test satisfies these conditions but Wald's $|\ t\ |$--test does not satisfy these conditions and in fact cannot satisfy a strengthened form of the Wald inequalities in general. Nonetheless, simulations show Wald's inequalities for the boundaries A, B, corresponding to usual small probabilities of error (alpha, beta) will usually hold.

Conflict of P-values and posterior probabilities has received substantial attention in statistical literature. Moreover, Bayesian P-values have been proposed in literature as alternative to classical P-values. We have reviewed the relation between P-values and posterior probabilities, and also the Bayesian P-values for composite null hypothesis when there is no alternative. Some new results have been obtained in the process. In particular, we have obtained some asymptotic results comparing the P-value with likelihood ratio and Bayes factor and argue that a part of the conflict between them arises from different choices of the framework for asymptotics.

In our work in Brain imaging, we have employed Bayesian methods on a data-set obtained from the website of Keith J. Worsley. It is related to study of perception of pain. The methods are inspired by the paper Bayesian Spatiotemporal Inference in Functional Magnetic Resonance Imaging (C. Gossl, D.P. Auer, and L. Fahrmeir, Biometrics 57, 554--562, 2001).

In our work in robust discriminant analysis, we have developed classifiers based on weighted likelihood estimators based on certain minimum divergence criteria. These may be considered as robust alternatives to Fisher's discriminant analysis. Usefulness of the proposed methods has been explored by extensive simulation study and also by employing these on some real data sets.

Sumitra Purkayastha

A theorem of Molnar (PAMS, Jan. 2001) asserting that surjective maps $\Phi : C(X) \to C(X)$, where X is a compact Hausdorff space, which satisfy the condition $\sigma(f\Phi\ f\Phi g) = \sigma(fg)$ for all $f, g \in C(X)$ and $\sigma(f)$ refers to the spectrum for f, are essentially induced by homeomorphisms of X, was generalized in various directions :

(a) for function algebras defined on compact, (resp.) locally compact, spaces
(b) for $A(K)$ spaces where K is a Choquet simplex.

The results in (a) are joint work with N.V. Rao and (b) is on-going research with T.S.S.R.K. Rao.

A.K. Roy

Investigations were done on the extension of Helgason Fourier transform for L^1 and L^p functions on the Riemannian symmetric space. Some basic theorems of L^p-analysis like Wiener Tauberain

theorems, Hardy-Littlewood-Paley theorem, Hausdorff inequality, Benedicts theoram were proved on symmetric spaces in this set up using Helgason Fourier transform.

Rudra P. Sarkar

We have proved that no sigraph on the complete graph K_p $p \geq 6$ is graceful and also gave the characterization of graceful sigraphs on K_p, $p \leq 5$. This implies that there is no subset S of cardinality $p \geq 6$ from $\{0,1,2,\ldots, q-n\}$, such that each element of $\{1,2,\ldots,n\}$ occurs exactly twice and each element of the remaining set $\{n+1,n+2,\ldots, q-n\}$ occurs exactly once as absolute difference of pair of distinct elements of S, and also produces all such subsets of cardinality $p \leq 5$.

Let $G = (V,E)$ be a graph with $|V(G)| = n$ vertices and $|E(G)| = m$ edges. Let f be a function from the vertex set $V(G)$ to the set $\{1,2,\ldots, n\}$ such that for all vertices u, $\sum_{uv \in E(G)} f(v) = a$ which is a constant and independent of u. Then f is called sigma labeling of graph G and a graph which admits such a labeling is called sigma labeled graph. We have proved the following:

(1) there exist an infinite number of connected non-complete multipartite sigma labeled graphs,

(2) that every graph is an induced subgraph of sigma labeled graph and

(3) we have given the necessary and sufficient condition for the bipartite graph $K_{a1,a2}$ to be sigma labeled.

(4) we have proved that $P_n \times C_m$, $n, m \geq 3$ is not a sigma labeled graph and $L(m,n) = K_m \times K_n$ where $m, n \geq 3$ is not a sigma labeled graph.

(5) we have also proved that Toms Grid $C_n \times C_k$, $n, k \geq 6$ is sigma labeled if and only if $n = k \equiv 2 (\text{mod } 4)$.

Let $G = (V,E)$ be a (p,q) -graph. Let be a mapping from the edge set of G to set $\{1,2,\ldots, k\}$ where $k \geq 0$, such that at each vertex all the numbers are present as edge labels (incident edges may have the same labels). Such a labeling ϕ is called edge k-cover labeling of graph G. If at each vertex all the k numbers are present as edge labels, then such labeling ϕ is called a saturated k-edge cover labeling of G and the maximum such k is denoted by $s(G)$. We have proved that for any graph G with the minimum degree $\delta(G) \geq 2$, $\delta(G) - 1 \leq s(G) \leq \delta(G)$.

Tarkeswar Singh

We (jointly with A.S. Hedayat, UIC, Chicago, USA) worked on an intriguing problem to assess the almost negligible chance of electronic toys generating electric shock to child users. We worked on a sampling strategy to generate necessary data and developed the underlying theory of point estimation and variance estimation. Then we carried out the data analysis and gave our recommendations.

We (jointly with T.J. Rao, ISI, Kolkata and T. Srivenkataramana, Bangalore University), investigated the monotonicity property of the first order and second order inclusion probabilities as functions of the underlying normed size measures for the Rao-Hartley-Cochran sampling scheme. The results throw further light on the basic premises for use of auxiliary information in survey smpling.

We (jointly with N.K. Mandal and K. Das of Calcutta University), examined the constructional aspects of optimal covariates' designs. We were able to give a very clear and meaningful insight into the underlying structure of the covariates' matrices which was missing in the literature. We provided some series of optimal designs.

We (jointly with K.R. Shah, University of Waterloo, Canada), worked on some aspects of Data Envelopment Analysis (DEA). The earlier work centered on what are known as "TOPSIS" and "ELECTRE" methods. We could establish that neither of the two methods satisfies certain basic

requirements for DEA. We suggested two modifications to the existing formulae. We also carried out necessary data analysis.

Work is going on in Data Analysis for Dyadic Models and Finite Populstion Inferential aspects of Social networks, Reliability Estimation using broken samples, Study of Pareto Optimal Subsets in Market Research Strategies and Statistical study of Apportionment Indices for use in forestry research.

Bikas Kumar Sinha

The problems of estimating finite population mean vector $\mu(y) = (\mu_1(y), .., \mu_s(y))'$ have been considered under various situations. Some new estimation procedures have been suggested and their efficiencies are found to be higher under empirical investigation. The optimum set of selection probabilities $P = \{p_1, ... p_N : p_i > 0, \sum_{ieu} p_i = 1\}$ based on size measures $X = (x_1, .., x_N)$ for estimating single mean or mean vector $\mu(y)$ have been obtained under superpopulation model.

T.P. Tripathi

Stat-Math Unit, Delhi

Research activities

The work on generalized inverses of partitioned matrices was continued. Some classes of outer inverses were charactenzed using certain rank equations. An explicit formula for the inverse of the resistance matrix of a graph was obtained, generalizing the formula known for trees.

R. B. Bapat

Methods for proving the positive definiteness and the infinite divisibility of matrix expressions were developed. Several-variable versions of some classical matrix inequalities were proved. Equations generalising the classical Lyapunov equation were studied.

Rajendra Bhatia

We continued to study Robustness properties of the optimal filter in nonlinear filtering. In particular, we studied the case of linear filtering when the observation noise is an Ornstein-Ulhenbeck process, computed the filter explicitly and showed that the filter converges weakly to the optimal filter in the 'standard model' in nonlinear filtering theory when the OU process tends to a standard brownian motion.

We also continued our work on martingale problems and their solutions - in particular - on characterization of Markov processes via martingale problems.

We looked at a problem in Stochastic Control and got some new results on existence of optimal Markov Solutions for ergodic control of Markov processes.

Abhay Gopal Bhatt

Obtained efficient block designs for Symmetric Parallel Line Assays with Block Size odd.

Ashis Das

Obtained optimal block designs for diallel crosses to estimate linear functions of general combining ability effects in the presence of specific combining ability effects. Also obtained Optimal Diallel Cross Designs for Estimation of Heritability.

Obtained optimal fractional factorial plans for asymmetric factorials for main effects and specified interactions.

Aloke Dey and Ashish Das

Obtained optimal crossover designs under nonadditive mixed effects model.

Aloke Dey

Continued with statistical inference problems for associated random variables- and also uniform and non-uniform Berry-Esseen bounds for associated random variables.

Also continued with the study of copmpeting risks – developed parametric models for sub-distribution functions and devised tests for independence of failure time and cause of failure.

Used nonparametric tests for comparison of distribution functions of the self help groups and non self help groups in a micro-finance study.

Isha Dewan

Continued the research work in Martingale problems, Markov processes and Filtering theory.

Rajeeva L. Karandikar

The problem of comparing the degree of association between two pairs of ordered random variables was considered. A notion of relative monotone regression dependence (or stochastic increasing) was considered. Using this concept, it was proved that for $i<j$, the dependence of the j th order statistic on the i th order statistic decreases as i and j draw apart. Similar results were proved for generalized order statistics. Also continued research on nonparametric inference for competing risks problems.

Subhash C. Kochar

We have been working on noncommutative geometry and its interplay with quantum groups. The case of the quantum SU(n) was investigated in some detail to see if Connes' formalism works well for this group. To do this, a new, essentially combinatorial technique to study Dirac operators on noncommutative spaces was initiated.

Arup Pal and Parthasarathy Chakraborty

Worked on statistical inference problems for stochastic processes governed by stochastic differential equations driven by fractional Brownian motion; continued work on probabilistic as well as inferential aspects for associated sequences of random variables jointly with Prof. Isha Dewan and on large deviation inequalities for MLE and BE for parameters of some SPDE's jointly with Prof. M.N. Mishra of Institute of Mathematics, Bhubaneswar; obtained characterizations of some probability distributions via binary associative operation in a joint work with Prof. Pietro Muliere of University of Bocconi, Milan and derived limit theorem for maximal segmental score for partial sums of random number of i.i.d. random variables in collobaration with Prof. M. Sreehari of Baroda University, Vadodara.

B. L. S. Prakasa Rao

Worked on problems on random graphs and percolation theory. Also wrote two articles on the history of mathematics.

Rahul Roy

Worked on random graphs and some models of percolation theory. Also worked on the convergence of partial sums of records.

Anish Sarkar

Stat-Math Unit, Bangalore

Research Activities

For the first time existence has been shown of dilations of completely positive semi- groups to $\cdot$-endomorphism semigroups which are not minimal but still 'atomic' in the sense that they have no 'smaller' dilations. It has also been shown that such a phenomenon cannot occur for unital semigroups or for regular dilations.

In the paper 'Standard non-commuting and commuting dilations of commuting tuples' it is shown that standard commuting dilation sits as the maximal commuting piece inside the standard non-commuting dilation. This work and some related work has led to the PhD thesis of Mr. Santanu Dey. Hilbert module product systems of Evans-Hudson flows have been computed in joint work with M. Lindsay.

Swarnajayanthi Fellowship project

Finalized the work on product systems of Hilbert spaces arising from sum systems. We extend Shale's Theorem and prove an old conjecture of K. R. Parthasarathy on this topic. These results are used to obtain a Functional Analytic construction of Tsirelson's exotic examples of product systems, which has been obtained using Probability Theory ('slightly colored noises').

B.V. Rajarama Bhat

Continued work on the Tate Conjecture for divisors analogue for normal varieties.

Jishnu Biswas

Research has been carried out in understanding the finite projective plane from the point of of linear algebraic codes. In particular, efforts are made to understand the minimum weight of the code generated by the lines of a finite projective plane of prime order.

Shreedhar Inamdar

A study is done on the semilinear elliptic problem with critical nonlinearity and an indefinite weight function, namely $\Delta u = \lambda u + h(x)\, u^{(n+2)/(n-2)}$ in a smooth domain bounded (respectively unbounded) $\Omega \subset \mathbf{R}^n$, $n > 4$, for $\lambda \geq 0$. Under suitable assumptions on the weight function, obtained the positive solution branch, bifurcating from the first eigenvalue $\lambda_1(\Omega)$ (respectively 0, the bottom of the essential spectrum).

A relationship between stationary isothermic surface and uniformly dense domains has been established. A stationary isothermic surface is a level surface of temperature which does not evolve with time. A domain Ω in the N-dimensional Euclidean space $\mathbf{R}^N$ is said to be uniformly dense in a surface $\Gamma \subset \mathbf{R}^N$ of codimension 1 if, for every small $r > 0$, the volume of the intersection of Ω with a ball of radius r and center x does not depend on x for $x \in \Gamma$. We have evidence to think that every uniformly dense domain which is bounded (or whose complement is bounded) must be a ball. Then we examine a uniformly dense domain with unbounded boundary $\partial\Omega$ and show that the principal curvatures of $\partial\Omega$ satisfy certain identities. The case in which the surface Γ coincides with $\partial\Omega$ is particularly interesting. In fact, it is shown that, if the boundary of a uniformly dense domain is connected, then (i) if $N = 2$ it must be either a circle or a straight line and (ii) if $N = 3$, it must be either a sphere, a spherical cylinder or a minimal surface. Discussion is concluded on uniformly dense domains whose boundary is a minimal surface.

Jyotshana Prajapat

There is a vast literature available on the growth properties of compactly generated groups but not much is known about general locally compact groups, especially non-compactly generated groups. The growth properties of p-adic Lie groups were considered. It may be noted that many p-adic Lie groups are not compactly generated. The focus is on the connection between growth and the eigenvalues of elements in Ad (G) and on showing that any p-adic Lie group which is not of type R has exponentially growing compact neighborhoods of identity.

The next consideration is on groups admitting recurrent random walks. Such groups are called recurrent groups. A conjecture of Guivarc'h and Keane says that a locally compact group is recurrent if and only if it has polynomial growth of degree at most two, that is, for every compact neighborhood K of identity in G there exists a constant c such that $m(K^n) \leq cn^2$ for all $n \geq 1$ where m is a left-invariant measure on G. The natural growth conjecture of Guivarc'h and Keane for p-adic Lie groups and for groups of polynomial growth whose connected component of identity is compact is being investigated.

The Choquet-Deny Theorem is valid for a probability measure μ on a locally compact group if constant functions are the only continuous bounded μ-harmonic functions. The validity of Choquet-Deny Theorem for any probability measure on compactly generated p-adic Lie groups of polynomial growth is being examined. It is also shown that polynomial growth is a necessary and sufficient condition for the validity of Choquet-Deny Theorem for any spread-out measure on p-adic algebraic groups.

A counter-example is also provided (a discrete extension of the p-adic Heisenberg group) to show that results proved above are not true for general p-adic Lie groups.

C.R.E. Raja

Research into infinite dimensional stochastic analysis / stochastic processes is being conducted worldwide along a wide front. Contributions to this area has been to identify and explicate the role of a class of equations that K. Ito calls 'type 2' equations. It is shown that the classical stochastic differential equations of Ito with smooth coefficients, can be viewed as 'type 2' equations on an appropriate scale of 'sobolev spaces'. The approach that has been taken to study SDE's also throws new light on the connection between partial differential equations and stochastic processes. The general solution of the heat equation for the Laplacian using the Ito formula as a 'type 2' equation has been reconstructed. Work on the heat equation for more general elliptic operators is in progress. An interesting side light of this approach is the role of the adjoint operator. The role of the adjoint has been somewhat of a mystery in the classical approach.

Work on Martingale Representation theorem

This is continuation of earlier work with P. Fitzsimmons. The stochastic derivative' introduced earlier can now be put on a rigorous footing. Also of interest is an explicit' formula for conditional expectations on the Wiener space. The formula generalizes to other Markov processes.

Time change by last entrance times (σ_t) and the induced transformation ($X_{\sigma_t} X_t - X_{\sigma_t}$) were introduced by the author in his thesis and its semi-martingale properties studied in later work. A question of some interest is: What happens to the Markov properties on (X_t) under this transformation ? For a Brownian motion (Xt) and $\sigma t = \sup\{s \leq t: X_s \in (a,b)\}$ it is shown that the process $Zt = (Xt \cdot X\sigma t, X\sigma t)$ is (strong) Markov for appropriate initial conditions, and we identify its transition function and prove its semi-group property.

B. Rajeev

Work on reflected Markov processes and the Skorokhod problem was continued. An expression for the transition probability density function of a reflected symmetric stable Levy process in an orthant was obtained, and shown to be continuous in the interior; the reflection terms could have fairly general time and space dependancy.

S.Ramasubramanian

Geometry of Banach spaces

A well-known result of Kadison that describes surjective isometries of the space of operators on a Hilbert space has been extended to the space of operators between Banach spaces, for a large class of Banach spaces. A partial solution to the local surjectivity problem on L(X,C(K)) was obtained by showing that when X is both uniformly convex and uniformly smooth and K is first countable, any local surjective isometry is a C(K)-module map.

Work done under externally funded projects :

Banach algebra techniques and the geometry of Banach space

Developed an abstract theory of unitaries in Banach spaces and studied Russo-Dye type theorems. It has been shown that for the space of operators that the unit ball is the closed convex hull in the strong operator topology of the set of unitaries is equivalent to the convex trasitivity of the underlying space.

Studies in Geometry of Banach Spaces

Using renorming techniques it has been shown that unlike the case of a von Neumann algebra, in a general dual space, weak*-unitaries need not attain their norm. A class of Banach spaces where

extreme points remain extreme in the unit ball of the fourth dual but not in the unit ball of the sixth dual were exhibited. These results indicate that it is not possible to have a notion of extremality that agrees with the usual notion for reflexive spaces but remains the same in all the duals of even order in the non-reflexive case.

T.S.S.R.K. Rao

The intersection pattern of the Ree groups in $G_2(3^{2n+1})$ were determined. The submodule structure of the code generated by the finite regular generalized quadrangles as a module for the orthogonal groups were determined. Substantial look towards the determination of the maximal subgroups of finite groups of the type F_4 was carried out. Expository writing on the Monster simple group, the theory of buildings and Coxeter groups was continued.

N.S.N. Sastry

Properties of Dunkl translation and convolution were studied. Maximal functions, multipliers and singular integrals associated to Dunkl transform have also been investigated.

The heat kernel transform for the Heisenberg group has been investigated. It has been proved that the range of this transform is not a weighted Bergman space which is in sharp contrast to the case of compact Lie groups and R^n.

S. Thangavelu

Study is being done for nonzero rational numbers a, b and rational polynomials C(y). Diophantine equations of the forms

$$a\,B_m(x) = b\,B_n(y) + C(y),$$
$$a\,B_m(x) = b\,f_n(y) + C(y), \text{ and}$$
$$a\,f_m(x) = b\,B_n(y) + C(y)$$

with $m \geq n > \deg C + 2$ for solutions in integers x, y. Optimal finiteness theorems have been proved in all cases.

If D is a division algebra with center a number field K and with an involution of the second kind, it is not known if the group SU(1,D)/[U(1,D),U(1,D)] is trivial. It is shown that if, by contrast, K is a function field in one variable over a number field, and if D is an algebra with center K and with an involution of the second kind, the above factor group can be infinite in general.

Study is being done on the congruence kernel of an arithmetic lattice Γ in a rank one algebraic group over a local field k. It has been proved that, if Γ is cocompact (in particular, when char k = 0), then the congruence kernel C is isomorphic to $\hat{F}_\infty$, the free profinite group on countably infinitely many generators. It has also been proved that, if Γ is non-uniform, then C is a free profinite product of $\hat{F}$, and nilpotent pro-p groups, each of class at most 2 and each generated by elements of p-power order, where p = char k. Several identities involving binomial coefficients have also been proved.

B. Sury

Applied Statistics Division

The Applied Statistics Division came into being in September 1996 in place of Applied Statistics, Surveys and Computing Division. The Computer Science Unit was renamed as the Applied Statistics Unit and the Biometry Unit was transferred to the Biological Sciences Division. Thus at present, the Applied Statistics Divison consists of only one unit viz. the Applied Statistics Unit.

The following are the research and other activities of the Applied Statistics Unit of the Applied Statistics Division during the year.

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.

Research and Other Scientific Activities

Sample Surveys

In complex surveys, compulsory versus optimal randomized response techniques were studied. Further research was carried out in examining consequences of cutting down the scale of a sample survey. Bootstrap techniques were extended to complex 2-stage survey sampling and small domain statistics were developed in complex multi-stage sample surveys.

Arijit Chaudhuri

Research was done in adaptive sampling and methods devised for keeping the final sample size in check.

Arijit Chaudhuri and Mausumi Bose

Audit sampling was done by multistage sampling technique with varying probabilities for selecting the first stage units.

Arijit Chaudhuri, Arun Adhikary, D.K. Chaturbedi and Kasturi Basu

Design of Experiments, Combinatorial Methods and their Applications

Crossover designs where both the number of periods and treatments are arbitrary were studied and in approximate design theory, necessary and sufficient conditions obtained in the form of linear equations, for the design to be universally optimal for carry-overs. The existence of optimal "symmetric" designs was proved and a method given to obtain it.

Latin Square Designs based on orthogonal arrays were used to obtain a class of new (2,n) visual cryptography schemes (VCS). These new schemes cover a wide range of values and are improvements over the existing schemes. Study is continuing on use of PBIB designs in developing new classes of (2,n) VCS and some highly efficient schemes have been obtained.

Mausumi Bose

Clinical Trials

Adaptive designs for phase III clinical trials were studied. Some suitable designs for continuous type of treatment responses were proposed and their properties and performances were studied. Particularly some possible extensions of the recently developed drop-the-loser rule were made, namely, for continuous responses, categorical responses and when covariates are present. Some optimal adaptive designs were also studied. Some Odds Ratio based adaptive allocation designs were studied.

Some adaptive allocation designs were theoretically and numerically studied in the survival analysis set up, i.e., when the data pertain to life-time.

Some crossover designs were also studied in the context of adaptive phase III clinical trials with binary treatment responses. Some theoretical properties were developed.

The problem of finding optimal dose levels in a phase I trial was studied.

Some non-parametric methodologies are being worked on for the design of Phase 1 and Phase 2 clinical trials to investigate the Maximum Tolerated Dose (MTD) and Efficacy of a test drug

Atanu Biswas and Anup Dewanji

Reliability and Survival Analysis

A new modeling has been developed in the software reliability context to investigate reliability of a Flight Control Software developed by ISRO. The new model is being analyzed with data from ISRO.

Anup Dewanji and Debasis Sengupta

Parametric and non-parametric methods are being developed to study estimation of the distributions of Quality Adjusted Lifetime (QAL).

Anup Dewanji and Debasis Sengupta

A robust parametric method has been developed for censored survival data. The method adapts some density based minimum divergence techniques which have been successfully used earlier in the case of complete (fully observed) data for standard parametric models. A major advantage of the method is that it does not require any non-parametric smoothing for producing a data based density estimate for the true density function.

Ayanendranath Basu

Statistical Genetics

An age-of-onset correction was proposed for the Sib-TDT via Cox Proportional Hazard Model. An existing non-parametric method for mapping quantitative traits based on sib-pair data was extended to incorporate sibship data. A regression strategy using multivariate phenotypes for mapping complex traits was developed, which circumvents many distributional and data-reduction problems encountered in existing methodologies.

Saurabh Ghosh

Inference

An adaptive rank based test procedure for the equality of two distribution functions was developed using partial sequential sampling scheme and Wilcoxon score.

Atanu Biswas

The problem of finding fixed-width confidence intervals for different adaptive designs was studied.

Atanu Biswas

Distribution of log odds ratio and the Mantel-Haenzel estimator was theoretically and numerically studied in some dependent cases.

Atanu Biswas

Bayesian analyses of bivariate ordinal data with covariates was done with application to some real epidemiological data.

Atanu Biswas

A new algorithm was developed for the computation of density based minimum divergence estimators, gaining a lot in simplicity without giving up a substantial part of the efficiency.

Ayanendranath Basu

A set estimator was developed in high dimensions; the method is automatic and its implementation is simple.

Ayanendranath Basu

Cryptology

Research was carried out in different areas of cryptology as indicated below.

Boolean functions: Subhamoy Maitra and Palash Sarkar

Design & analysis of symmetric ciphers: Bimal Roy, Subhamoy Maitra and Palash Sarkar

Hash functions: Bimal Roy and Palash Sarkar

Implementation of elliptic & hyperelliptic curve cryptosystems, bilinear pairing based Protocol : Palash Sarkar

Visual cryptography: Bimal Roy

Steganography & digital watermarking: Subhamoy Maitra

Algebraic properties of 2D-cellular automata

The nine variable linear Boolean functions (total 512) were divided into nine groups depending on the number of variables. Several matrix algebraic properties were observed interrelating these groups of functions. Further, on using the concept of Jacobean matrix, the state transition diagrams of several nonlinear Boolean functions were found to be quite regular and systematic.

Pabitra Pal Chowdhury

Pattern Recognition with SODAR Data

The acoustic echo sounder or sodar is a radar-like instrument designed for remote probing of the lower atmosphere. The data it generates provides valuable insights into the turbulence patterns in the lower atmosphere, that are useful to meteorologists, communication scientists, aviation authorities, and so on. Pattern recognition techniques were used on these data for identifying two of the typical categories of atmospheric conditions, namely, thermal plumes and inversion. A chunk of the data was treated as an image over time, and the boundary between the turbulent and non-turbulent regions, as observed in the data, was estimated using various statistical (Maximum Likelihood and Bayesian) change-point detection techniques. This boundary was treated as a time series, and three different sets of features were proposed on the basis of the Fourier transform of this time series. Some standard classifiers, like the Bayes and the k-nearest neighbour, were constructed for distinguishing between the two classes of patterns. The results obtained are encouraging.

Amita Pal

Other areas

Some work on the measure of social mobility with respect to several social indices was carried out with reference to data on the intergenerational mobility of Scheduled Caste population in two districts of West Bengal.

Anup Dewanji and Bimal Roy

A method was developed to evaluate a training programme with reference to a training programme conducted by State Institute of Panchayat and Rural Development (SIPRD), Kalyani, West Bengal.

Anup Dewanji and Bimal Roy

Projects:

Internally Funded Projects

Bayesian analysis of SODAR data

Bayesian image processing and pattern recognition techniques are being successfully implemented for automatic categorisation of structures observed in SODAR (Sound Detection and Ranging) data obtained from Antarctica during 1995-96.

Air pollution modelling

The aim of this project is to develop mathematical models which can be used to analyze the huge volume of data collected by various Pollution Control Board's in India, in a periodic, non-uniform, irregular patterns, over time – to find trend over the years, seasonality patterns, estimation at distant places, and future prediction of pollutant concentrations.

Approximation to high-dimensional model selection criteria and evaluation of performance.

The aim of the project is to develop approximation to high-dimensional model selection criteria and evaluation of their performance. An approximation to Bayesian model selection criterion for high-dimensional models has been proposed and this has been successfully employed in a complicated example from ecology with a large data set.

Construction of Boolean functions of cryptographic importance

A class of new single variable and multi-variable Boolean functions of cryptographic importance have been constructed.

Implementation of provably secured public key protocols

The aim of the project is to develop and implement secure protocols. This requires the development of a library for doing arithmetic with large numbers. Currently, we have partly developed such a library and have implemented RSA-OAEP, a provably secure variant of RSA.

Robust estimation and goodness of fit tests for circular models

Robust estimators of circular parameters are derived and their exact properties are studied. Distributions of rotationally invariant goodness-of-fit tests are derived and their cut-off-points are tabulated for a general class of circular distributions.

Studies of algebraic properties of 2D-cellular automata

Matrix algebraic properties interrelating various groups of nine-variable Boolean functions were studied, together with the state transition diagrams of several nonlinear Boolean functions.

Developing Audit Sampling tools for PWD, PHE and I&W

Multistage sampling was used with varying probabilities for selecting the first stage units.

Externally Funded Projects

Reliability Assessment of a solid Rocket Motor

The reliability (probability that the various performance parameters will have values within specification limits) was estimated in terms of various explanatory variables, using data from tests as well as actual flights.

Evaluation flight control software

A model was developed for predicting the probability of no failure of the software during flight time, using past failure and complexity data on various modules of the software.

Cryptanalysis of complex LFSR based systems

A faster algorithm has been designed for recovery of the connection polynomials of the LFSRs. A model that assumes Markov process of higher order, has been used to estimate the combining Boolean function having memory.

Visual cryptographic schemes

A software has been developed to implement a visual threshold scheme for B&W pictures.

Design aid/tool for selecting & testing of connection polynomials

Algorithms for construction of primitive polynomial of degree ≤ 128, that do not have sparse multiples of degree less than 5000, have been developed & implemented.

Development of Cryptographic protocols based on Weil and Tate pausing on elliptic curve

Efficient Algorithms are being designed for multi-party key exchange and short digital signatures that will be useful for e-governance & e-commerce.

Steganographic Schemes for Satellite Images for ISRO

Efficient Steganographic schemes which suit satellite images (i.e. for the images where most of the part may be of little information) were studied.

Cryptanalysis and design of steganographic schemes

Steganographic schemes were considered as Cryptographic models and cipher text only jamming attacks and their remedies were studied.

Development of an Indigenous Block Cipher Scheme for ISRO

The goal is to develop a large family of ciphers with security against known attacks to be as good as that of AES. Theoretical work on identifying properties of AES, which can be varied, has been done. Also a s/w has been developed to randomly generate a variant of AES.

Computer and Communication Sciences Division

The Division comprises Advanced Computing and Microelectronics Unit, Computer Vision and Pattern Recognition Unit, Electronics and Communication Sciences Unit and Machine Intelligence Unit. Faculty members of the Division are engaged in teaching and training related to M. Stat., M. Tech. (CS), and M.Tech. (QROR) programmes, in addition to their research and project work. Many undergraduate and postgraduate engineering students of Computer Science, Electronics and Telecommunication, Electrical Engineering, and students of MCA courses from several universities and institutes undergo their vocational/semestral training under the supervision of the faculty members of this division. Research work carried out in these units is summarized below.

Advanced Computing and Microelectronics Unit

Research and Other Scientific Activities

During the period under review, the faculty members of the unit were engaged in research in Low-power Logic Design for Testability, Image Processing Architecture, Development of Course Module on Data Structures (for the North-Eastern States) besides the areas of Computer Science as presented below.

Facility Location Problems

This is an important research area with several practical applications, for example, in mobile computing, path planning, garbage disposal, to name a few. Given a set of demand points, a distance function and a parameter k, the problem is to find a set of k supply objects (points, lines, segments, etc.), which minimizes some objective function related to distances, for example, the maximum distance between a demand point and its nearest supply, or the sum of distances of all demand points to their nearest supply. The aim of this project is to investigate some special cases of these problems, such as linear/non-linear facility location, obnoxious facility location, polygonal obnoxious facility location etc., and designing efficient tools that help to generate optimal solutions in polynomial time if possible.

The closest/farthest point problems and their generalizations arise in different areas of the facility location problem. Designing efficient algorithms for different versions of the k-nearest neighbour problem for lines and segments and k-point clustering problems among a set of points distributed on the plane play key roles for designing efficient algorithms for various facility location problems. We developed efficient algorithms for these problems. For the k nearest neighbours of a line, the preprocessing time of the demand points in 2D needs $O(n^2)$ time and $O(n^2/\log n)$ space, and the query time is $O(k + \log n)$. For the k nearest neighbours of a line segment, the preprocessing time and space are both $O(n^2)$, and the query time is $O(k + \log^2 n)$.

We have also studied different variations of k-point clustering problems. The objective is to find the minimum area rectangle and square (of arbitrary orientation) such that it contains exactly k points. This problem is optimally solved in $O(n^2 \log n + kn(n-k)(n-k+\log k))$ time and $O(n)$ space. Another variation of this problem is the colour-spanning rectangle problem, where each point is attached with a colour from a set of k distinct colors ($k << n$), and the objective is to get the minimum area rectangle containing at least one point of each colour. We have designed an algorithm for this problem which works in $O(n^2 \log n)$ time using $O(n)$ space.

S.C. Nandy, S. Das, N. Das and J. Dattagupta

Multi-layer VLSI Routing

The motivation of topological routing is to solve the problem of global routing for a given netlist and placement of modules efficiently, without having the restriction of pre-defined shapes of routing regions. Typically, the nets are routed one by one. For each net, the shortest Steiner tree connecting all the terminals avoiding a set of obstacles is to be determined. The ordering of the nets plays a critical role in achieving 100% success in routing. Re-ordering of the nets cannot guarantee completion even though a solution may exist because most of the existing routers emphasize on determining the shortest path at every stage.

An alternative approach is to consider all the nets concurrently and connect the pins of all nets simultaneously. We assume the obstacles to be arbitrary convex polygons. Although this may seem unusual for the state-of-the-art VLSI chip technology, this situation arises if we have to consider pre-routed special nets or groups of pre-placed and routed blocks which are obstacles for the router.

An algorithm for obtaining a sketch, i.e., a topological routing of nets having multiple terminals on one layer in a concurrent manner, has already been devised. Hence in this project, the following two related sub-problems are being addressed: (i) extend the topological algorithm to multiple layers, where each layer may have polygonal obstacles; (ii) algorithm for detailed routing of the sketch using Manhattan and diagonal wires on multiple layers.

The primary objectives are to reduce delay, crosstalk and number of layers. The performance of these algorithms will be critically analyzed and results on benchmarks compared with those produced by standard routers.

The routing model used is unreserved layer in which wire segments in a layer may be in any of the pre-assigned directions, typically horizontal and vertical. A graph depicting reachability of routing regions is extracted by employing a sweep-line technique and then a search heuristic is applied to determine a potential Steiner tree for each net. Next, the layer assignment problem has to be solved followed by finding non-crossing rectilinear paths for wire segments of each net on each layer.

> A polynomial time algorithm for determining non-crossing rectilinear paths for wire segments of each net on each layer has been designed and implemented. Computational geometric properties and data structures are used.
>
> Partitioning of the routing area into zones having no common nets tends to accelerate the topological router; thus an efficient heuristic for this NP-complete problem was designed. Additional constraints of non-overlapping zones with high priority for convex shapes have been incorporated in the design of the graph-based heuristic for this problem. At the core of the heuristic lies a clique-partitioning formulation.

Lack of industrial benchmarks to date has made it difficult to test the robustness and the scalability of the implementations.

S. Sur-Kolay, B.B. Bhattacharya, S.C. Nandy and S.Das

Checkpointing In Distributed Systems

Checkpointing in distributed message passing systems is difficult to implement as it requires finding Consistent Global Checkpoints. Though algorithms exist for checkpointing with multiple concurrent initiations for general topologies, the performance of the existing algorithms is poor for the simple *ring* network. Checkpointing and recovery schemes have been proposed which work for the unidirectional and bi-directional *ring* networks. These algorithms outperform the existing algorithms in terms of number of messages and time. A new scheme for checkpointing and recovery using mobile agents has been proposed.

There are several schemes for checkpointing and rollback recovery. Performance analysis is very important for the utility of these schemes. A performance analysis of different checkpointing and recovery schemes has also been done using a stochastic model. It has been done on the basis of expected cost of checkpointing, rollback recovery, message logging and piggybacking with application messages in synchronous as well as asynchronous checkpointing. For a quasi-synchronous checkpointing scheme the upper bound and lower bound of selective message logging has been calculated.

K. Mukhopadhyay

Wireless Networks and Mobile Computing

To cope up with the changing demand of channels in a wireless communication environment, a dynamic channel assignment scheme has been proposed that starts with a known demand but can accommodate new perturbations in demand with minimal rearrangement. Simulation studies on well-

known *Philadelphia benchmark* problems show that the algorithm performs better compared to the earlier ones, both in terms of computation time and blocking.

For ad hoc networks, a novel routing scheme based on *connected dominating set* has been proposed. Simulation studies show that the algorithm outperforms the earlier ones in terms of cardinalities of the dominating sets and number of message exchanges.

N.Das, B.P. Sinha, J. Dattagupta, K. Mukhopadhyay and S. Mukhopadhyay

Test Response Compaction for Sequential Circuits/System-on-a-Chip (S-o-C)

Designing of zero-aliasing space compactor for response compaction in a sequential circuit has been investigated. For scan-based sequential cores, a new technique has been developed to synthesize a zero-aliasing compactor based on a novel concept of distinguishing lines and characteristic function of the response matrix. The proposed compactor is applicable to any arbitrary sequential circuit, and provides single-output (maximum) compaction with zero (minimum) aliasing. This solves a long-standing open problem in compactor design: till date, it was believed that for a random circuit, zero-aliasing single-output compaction is impossible. Significant reduction of hardware overhead can be achieved by tolerating a negligible amount of aliasing.

B.B. Bhattacharya

Power Supply Droop Noise Modeling

While performance and density gains have soared up due to smaller transistor feature size, so has semiconductor power density. Microprocessors of today have power density of about 60Watts/Cm2, and this figure may be extrapolated to about 200Watts/Cm2 by 2010. This 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. On the other hand, delay sensitivity to power supply variation is also on the rise, thereby raising the importance of reliable distribution of power manifold. This issue has three facets: analysis of the problem, synthesis of power distribution network and targeted test development to expose performance impact when practical constraints limit us from designing a fully comprehensive power supply design. The first issue has been addressed and a methodology for modeling gate delay faults from power supply droop noise has been developed based on which the test pattern generation problem is being solved.

The circuit model for the distributed power grid has been studied in depth and with realistic values of parasitics extracted by public domain software on benchmarks, an accurate model has been proposed. Simulation set-up has also been tested on small examples but scalability issues are being tackled. Methodology for test pattern generation for power supply droop excitation has also been decided on.

S. Sur-Kolay and B.B. Bhattacharya

Fast FPGA placement methods

Field-Programmable Gate Arrays (FPGAs) are used extensively to synthesize complex logic circuits by programming. A promising FPGA placement approach has been designed. First the output cones are identified and these are placed one by one to obtain a very good initial placement. Then two iterative refinement algorithms have been proposed and implemented to yield very competitive placement solutions in terms of area, netlength and delay with time savings of upto 75% compared to commercial tools.

S. Sur-Kolay

Hybrid Architecture for Parallel/Distributed Computing

Hybrid architectures using both electrical and optical links for interconnecting processors in a parallel and distributed environment have gained importance over the last few years due to better characteristics of the optical links in terms of speed, power and cross talks. A new hybrid architecture called OMULT (Optical Multi-Trees) has been proposed with only three links per processor on which several fundamental algorithms such as summation, average, maximum/minimum, matrix transpose,

matrix multiplication, discrete Fourier transform, sorting can be all computed in $O(\log n)$ time (considering both communication and computation time). This may be contrasted with $O(n^{1/2})$ execution time of these algorithms on the OTIS (Optical Transpose Interconnection System) Mesh. Also, algorithms for some problems in computational geometry like convex hull, ECDF, ANN, etc have been developed on the OMULT architecture all of which can be executed in $O(\log n)$ time.

B.P. Sinha

On-Chip Implementation for Content-based Image retrieval

We address the content-based image retrieval (CBIR) problem using novel ideas of combinatorial characterization of an image, computational geometry, and data mining. Parameters like Euler Number, Euler Vector, geometric distribution of control points, etc. have been considered for characterization of an image. Applications to image database searching and fingerprint analysis have been studied. On-chip VLSI architectures of these algorithms have been designed. Future generations of personal and mobile computers are likely to provide on-chip implementation of CBIR to accelerate image searching and retrieval. CBIR has versatile applications to internet surfing, forensic, medical and geographical image processing. This work is currently being pursued under a collaborative project with MIU, ISI and Intel Corporation, USA. Eight patents have been filed at the US Patents and Trademark office.

B.B. Bhattacharya, M.K. Kundu and C.A. Murthy

Computer Vision and Pattern Recognition Unit

Research and Other Scientific Activities

Document Analysis

Systems for word-wise script identification from triplet-script documents in Devnagari, English and Telugu; Devnagari, English and Gujarati; Devnagari, English and Oriya have been developed. At present the system achieves an accuracy of about 97%. A modified scheme has been developed for word-wise identification of Bangla, Devnagari and English scripts. An improved character segmentation algorithm has been developed. A system for multi-oriented text line extraction has also been developed. For multi-oriented and multi-sized printed English character recognition, a system has been developed.

Under the externally funded project entitled "Handwriting recognition for postal automation" funded by Indo-French Centre for the Promotion of Advanced Research (IFCPAR), a database of about 7000 scanned images of envelopes, postcards, inland letters, etc. has been developed. The database is maintained in such a way that the destination and the language in which the address is written, can be understood from the file name. Such a database is useful to train and test a recognition system.A preprocessing module to separate the stamped region from the address part has been developed. A system to extract the pin code from the pin code boxes in the address region has been developed.A modified scheme has been developed to recognize the pin code written in Bangla as well as English.

A study of information content in different parts of Indian language scripts has been made. In this study it was established that Bangla and Hindi scripts contain predominant information in the upper half while Oriya script contains more information in the lower half.

U.Pal, U. Garain, B.B. Chaudhuri

Functional Magnetic Resonance Imaging

The trimmed least squares based algorithm for fMRI image registration has been further studied and extended. The performance of the algorithm in the presence of white Gaussian noise had been studied earlier. Modifications have been explored to deal with Rician noise, which is more common in fMRI images.

A wavelet-based scheme based on B-spline filters has been used for identifying the activation region, preceded by de-noising and its modification to include temporal changes. This has yielded very encouraging results. Performance of the algorithm has been extensively compared with that of standard softwares.

Sarban Palit, Sumitra Purkayastha and Debasis Sengupta

Handwritten Character Recognition

(i) A large database of 38,000 handwritten isolated basic Bangla character images has been developed. Two other databases of handwritten isolated Devnagari and Oriya numerals have also been developed. Also, a set of more than 25,000 samples of handwritten isolated Bangla characters with vowel modifiers and compound characters has been collected. (ii) Recognition performance for handwritten Bangla numerals using wavelet-based features has been improved by implementing a majority voting scheme. Also, a system for recognition of unconstrained Oriya numerals has been developed. (iii) For handwritten Bangla basic characters, two skeleton representation schemes have been developed. Shape features from one of them have been identified using EM algorithm. A database of such shape features has been developed on the basis of which an HMM based classifier will be designed to recognise individual characters. (iv) Systems for segmentation of unconstrained handwritten Bangla texts into lines, words and characters; for automatic separation of Oriya handwritten text into lines and words, for segmentation of English-Oriya handwritten touching strings and for touching string identification and segmentation have been developed.

U. Bhattacharya, U. Garain, U. Pal, S.K. Parui and B.B. Chaudhuri

Natural Language Processing

The spell-checker developed over the last few years has been improved by testing on a large amount of data, mainly newspaper corpus. The dictionary has been enriched, suffixes have been added and the rules have been modified to take care of the drawbacks. Also, rules for echo-word formation have been included in the spell-checker. Algorithms for tackling of compound words formed by joining two noun words have also been developed. The system has now become very powerful and nearly complete.

Another study of Bangla word re-duplication has been done in detail. Words of various parts of speech and other grammatical roles have been analysed for their re-duplicative role. The semantic roles of different re-duplicated words have also been studied.

Compilation of Bangla – English electronic dictionary has been completed. This dictionary has about 65,000 word entries and it may be searched in different modes. It can be used even when the exact spelling of a source word is not known.

B.B. Chaudhuri

Digital Data Compression and Security

An algorithm has been developed for compression of Indian language textual documents which gives a compression ratio that is better than that given by the standard algorithms CCITT Gr-4 and JBIG 1 which are publicly available. Detection of text lines and words has been implemented in the compressed domain. Word occurrence frequencies have been computed in the compressed domain. Several existing algorithms have been tested to study their usefulness for compression of Indian language electronic text data and a comparative study has been made. A test database containing 150 textual images has been developed. A scheme for watermarking still images, both gray-level and colour, has been devised to provide a measure of image degradation due to noise, which can serve as an important feature of quality assessment. A modification of the above scheme for images undergoing JPEG compression, is being explored.

U.Garain, S. Palit, and B. B. Chaudhuri

Information Retrieval

A large corpus of Bangla news articles containing over 50,000 documents has been constructed. The articles were obtained by crawling the website of a popular Bangla daily, and converting the crawled

text to a standard encoding. This is the first corpus of its kind, and will be very useful for empirical IR and NLP research in Bangla. Some elementary corpus statistics have been calculated for this collection. Investigations into sentence-level information retrieval and novelty detection has been initiated. Work on IR from biological documents has just started.

M. Mitra

A Generalized Transform for Signal Processing

A new and generalized transform for signal decomposition and reconstruction was developed which can be useful for signal processing tasks like compression, encryption etc. The proposed scheme has several advantages over the existing transforms like wavelets and filter bank. It is implicitly assumed in the signal processing community that the filters need to be of QMF or COF type in order to get perfect reconstruction of the original signal from its decomposed components. However, in the proposed transform, perfect reconstruction is possible with filters that are not necessarily of QMF or COF type. Also, in the existing transforms, finding perfect reconstruction filters is not straightforward while in the proposed scheme it is fairly simple. In the existing decomposition schemes, a signal is always decomposed into an approximation and a detail. But here a signal can be decomposed into an approximation and a detail or into two details or into two approximations, without sacrificing the reconstructibility property.

S.K. Parui and Y.K. Singh

Speech Analysis and Synthesis

A new approach to speech synthesis has been initiated. Our earlier approach was based on diphone concatenation. We now plan to use bigger units like CV, VC, CCV, VCV for the concatenation process. A new algorithm has been developed for amplitude normalization. Also, a morphing algorithm has been written to combine the two ends of two speech signals. Work has been done on the spectral characteristics of basic phonemic units like vowels. The formant frequencies of seven Bangla vowels have been characterized. The nasalized forms of these vowels have also been studied. Next, the diphthongs have been examined for their transitional properties between two vowels.

A laboratory for recording speech sound in a noise-free room has been built. This lab will be equipped with recording instruments soon.

B.B. Chaudhuri

Electronics and Communication Sciences Unit

Research and Other Scientific Activities

Mathematical Morphology and Its Application In Image Processing

Mathematical morphological algorithms have been developed for extraction and processing of various entities of document page images. The Algorithms have been successfully implemented to process the image regions containing mathematical expressions, content pages of books and journals, and subject index pages. Morphological algorithms for identification and processing of official forms have also been developed.

An algorithm for automatic generation of structuring element has been developed. The efficacy of this method is demonstrated by developing a Bengali numeral recognition system based on morphological operation with structuring elements generated by the algorithm.

B. Chanda

Image Compression

Work is being carried on to integrate two well-known spatial domain image compression techniques - block truncation coding (BTC) and vector quantization (VQ) using pattern fitting. The pattern code

book is generated using a clustering algorithm applied on the processed block of training images. Predictive coding and interpolation methods are used for further reduction of bpp.

A new performance measure has been proposed, and based on that the performance of our proposed technique of image compression using Kohonen's self-organizing feature map is reevaluated.

B. Chanda

Content Based Image Retrieval

Perceptual image features based on petal projection, texture co-occurrence matrix and fuzzy index of colour have been proposed. Shape features of segmented objects are computed based on a newly proposed scheme called 'petal projection'. Texel co-occurrence matrix is proposed using a newly defined texture unit 'texel'. A set of textural features is calculated based on this matrix. Perceptual colour features like redness, blueness etc. are computed as a fuzzy index obtained from hue histogram. Using these features, similar images are retrieved from a reasonably large database and the performance of the same is evaluated. For efficient retrieval, a multi-dimensional indexing scheme is proposed.

B. Chanda and D.P. Mukherjee

Estimation of Cloud Motion Vector

The proposed methodology for hierarchical, automatic identification of tracer clouds is based on feature extraction of neighbourhood information, segmentation of image features and identification of a set of compact potential regions of tracer clouds from the coldest cloud segments (for 3 successive image frames). The whole procedure is repeated and the correspondence among the segments of these frames based on shape/size etc. has been established. For correspondence, even in unequal number of segments, a suitable energy minimization function has been formulated and several chains of associated cloud regions are found. They are ranked using fuzzy reasoning to identify the 'best' tracer cloud sequence. Next CMV is estimated by calculating the set of relative displacement centroid of tracer sequence and the result is compared with the classical auto cross correlation method.

A.K. De and J. Das

Breast Cancer Detection using CI Tools

Prevention and early detection of breast tumors and micro calcification (cancer) are challenging problems and an immediate demand from society. Digital mammogram is a digitized image of the breast using low-dose X-ray. Microcalcification in the breast form groups of tiny bright spots on the bright part of the image. These spots are ignored by traditional image processing (IP) tools. In this context we thought computational intelligence (CI) tools are most suitable for this problem. some of the 0most important criteria to distinguish malignant calcification from benign are the morphological features namely size, shape, density, etc. of calcification. We intend to exploit these morphological characteristics using computational intelligence paradigms for detection of malignancy. We plan to develop methods for detection and characterization of micro-calcification and tumours. This will involve the following : i) development of perception model based enhancement techniques aided by expert provided fuzzy rules, ii) development of appropriate segmentation techniques (it may be noted that, conventional segmentation techniques do not work), iii) feature extraction and analysis, iv) designing of classifiers for detection and classification of breast cancer tumors (such as benign, malignant and calcifications). Here even some aiding tools for the doctors would be very useful.

S. Pal, N.R. Pal and J. Das

Forecasting using ANN

The main objective of this project is to study the forecasting techniques for atmospheric science applications using artificial neural network (ANN). Most of the conventional techniques are designed based on parameter estimation using statistical tools when the pattern of the data is a priori assumed to follow a particular distribution. In general this assumption does not hold because of some dynamic behaviour of environmental effects. This effect is not taken into account in the conventional method of forecasting. "Model free" computing tools like artificial neural networks, fuzzy logic etc. are expected to

do a better job in such situations. In this project, we emphasize forecasting of atmospheric temperatures (maximum and minimum), cloud motion etc.

J.Das, S. Pal and N.R. Pal

Machine Intelligence Unit

The faculty of MIU take active part in teaching and training in B. Stat., M. Stat., M. Tech. (Computer Science), M. Tech. (QR & OR) and CCPA/ DCPA courses. They also supervise M. Stat. and M. Tech. projects/dissertations besides Ph.D. theses. Many undergraduate and postgraduate engineering students of Computer Science, Electronics and Telecommunication, Electrical Engineering and students of MCA courses from different universities and institutes undergo their vocational/ semester training under the supervision of the faculty members of MIU.

Research and Other Activities

The objective of the Machine Intelligence Unit (MIU) is to carry out basic research concerning certain aspects of machine intelligence. Machine intelligence signifies the work associated with attempting to make a machine behave like a human being. In other words, it conveys the core concept of pattern recognition and machine learning with the advanced technologies like fuzzy logic, artificial neural networks, genetic algorithms, fractals, wavelets and rough sets.

The investigation that is currently being done in MIU comprises both the development of these technologies individually and in an integrated (hybridized) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, machine learning, image processing, expert systems, vision, data mining, bio-informatics etc. related to the design of intelligent systems. Hybridization such as neuro-fuzzy, neuro-rough, neuro-fuzzy-genetic helps in making such systems artificially more intelligent.

These tools collectively constitute what is known as the soft computing paradigm. They provide a theory of flexible information processing, which can deal with real life ambiguous situations in an efficient manner like human beings, and therefore form the basis of future generation computing systems.

Research work that has been carried out in the aforesaid line is categorized and given below.

Pattern Recognition

An algorithm for density based clustering using K-NN density estimation procedure has been developed.

C.A. Murthy

A technique for clustering data into arbitrary shaped clusters has been developed. The algorithm uses the concept of relative distances between two points. Two points that are distant in the feature space may be considered to be relatively close if there is a sequence of points that lies within these two points. Based on this observation, an automatic shape independent clustering technique has been demonstrated.

S. Bandyopadhyay

Image Analysis/Processing and Computer Vision

A hue preserving color image enhancement scheme has been developed for color images. This scheme generalizes the gray level image enhancement procedures to color images without possessing the gamut problem.

An automatic threshold selection procedure for edge detection in gray scale images has been developed using principles of statistics.

C.A. Murthy

A computationally efficient and robust image watermarking technique in transform domain has been developed. Experimental results indicate that the proposed technique is resilient to common external attacks like mean, median & Gaussian filtering, lossy compression (JPEG), cropping, scaling and change of dynamic range of intensity. One US patent on block based watermarking has been granted.

Analysis of various textured images has been made. M-band wavelets have been used to segment textured images for real life image analysis. Extraction of features using M-band wavelet packet frame and their neuro-fuzzy evaluation for multi-texture segmentation has been completed.

Content Based Image Retrieval (CBIR) is another important research area of MIU. An efficient technique for gray tone image corners using fuzzy set theoretic approach has been developed. CBIR using visually significant multi-scale edge corner points and a colour feature has also been developed. The performance of such characterization for a CBIR system was tested on a variety of benchmark databases like trademark database, Olivetti and COIL picture databases and the results were found to be satisfactory. One US patent on a new distance measure based on Mahalanobis distance has been granted.

M.K. Kundu

An algorithm for segmentation based gray level image data compression has been developed.

S. Biswas

Data Mining and Knowledge Discovery

An algorithm for generating support vectors with probabilistic query has been developed in the context of data mining.

S.K. Pal and C.A. Murthy

Genetic Algorithms (GAs)

An automatic fuzzy clustering technique where the number of clusters is not specified a priori has been developed. The technique makes use of the searching capability of genetic algorithms for this purpose. In order to keep the number of clusters variable, the string length in GAs is also kept variable, and appropriate operators are defined. In this context, new cluster validity indices, for both crisp and fuzzy clusters, are proposed and utilized in the genetic fuzzy clustering technique. The effectiveness of the proposed technique is demonstrated on several artificial and real life data sets, including some satellite images.

S. Bandyopadhyay

A new genetic operator has been developed which models the influence of the ancestors on siblings.

S.K. Pal

Fractals and Wavelets

A robust and computationally fast technique for multi-class texture segmentation using multi-scale M-band wavelet filter has been developed. This is found to be extremely useful for the segmentation of text and graphics in unstructured and complex (overlapping text and graphics) document images. Here a document image is decomposed by M-band wavelet filter into a set of M X M band-pass channels. Various combinations of those channels represent the image at different scales and orientations in the frequency plane. Measuring the local energy around each pixel at different scales, a map of feature vector is formed. This scale-space signature with traditional k-means clustering algorithm is used to develop a robust document image segmentation technique, which is nearly independent of font size and type, scanning resolution, rotation, skewed transform, type of layout (irregular/regular) and non-convex overlapping of text & graphics. The method is found to be superior to many existing popular techniques. Segmentation of remotely sensed images as well as of complex documents has been done using wavelet features. Their evaluation has also been done in a soft computing framework. One US patent has been granted on image compression using fractals. This is based on Iterated Function Systems with probability.

M.K. Kundu

Case Based Reasoning

An algorithm for generating cases using rough sets has been developed and its utility has been demonstrated on real-life data sets.

S.K. Pal

Neural Networks

An algorithm for architecture selection for multi-layer perceptrons has been developed using cross validation technique.

C.A. Murthy

Neuro-fuzzy techniques have been successfully utilized for classification in the context of radio-wave propagation.

S.K. Pal

Fuzzy Sets, Rough Sets and Applications

A new model of multi layer perceptron, namely rough-fuzzy MLP, has been developed by utilizing the concepts from rough set theory and fuzzy set theory. Its performance over the other existing methods has been experimentally demonstrated.

A rough set theory based classifier has been developed for which the feature space has been discretized using concepts from fuzzy set theory.

An algorithm for clustering has been developed using EM (expectation maximization) algorithm and rough sets which efficiently finds non-convex clusters.

S.K. Pal

Bioinformatics

An algorithm for three dimensional flexible search for molecular databases has been developed for chemogenomics.

C.A. Murthy

An algorithm for determining gene regulatory networks indicating the strength of gene-protein interaction has been developed.

R.K. De

Physics and Earth Sciences Division

Geological Studies Unit

Members of the Geological Studies Unit have been active in B.Stat. teaching programme and supervising research students enrolled in Ph.D. programme.

Research Activities

Penganga sequence and Neoproterozoic paleogeography

Lithostratigraphy of the early Neoproterozoic Penganga Group developed along the western side of the polyhistory Proterozoic rift basin has been reconstructed. The Penganga Group comprises a major progradational to retrogradational, unconformity bound rift sequence, bounded between the underlying Pakhal and overlying Sullavai groups. Northwesterly basin slope, and occurrence of a major seaway skirting the northern margin of the south Indian craton has been interpreted from palaeogeographic analysis of the Penganga sequence. The Mesoproterozoic Pakhal Group, on the other hand, had a southwesterly axial slope, and it opened up to a seaway to the east of the south Indian craton.

Asru K Chaudhuri et al.

Chattisgarh stratigraphy

Reconstruction of the stratigraphic succession in the eastern part of the Chattisgarh basin has been completed. A hitherto unreported unconformity at the top of limestone-shale dominated Raipur Group of the Chattisgarh Supergroup, has been identified. The unconformity is overlain by a sandstone sequence comprising a significant component of volcaniclastic sands. The sandstone and the overlying shale show profuse development of soft sediment deformation structures which may indicate seismic disturbance in the basin. The Neoproterozoic succession is unconformably overlain by the Talchir and Barakar rocks of late Palaeozoic – Mesozoic Gondwana succession. A rift origin of the Chattisgarh basin has been proposed and palaeogeography of the rift basin has been established. Northerly opening palaeogeography of the basin, connecting with a major sea-way towards north has been proposed.

Sarbani Patranabis-Deb and A K Chaudhuri

Calcite mylonite and oblique grain shape fabric

An inverse relation between obliquity of shape preferred orientation (SPO) and intensity of SPO as defined by recrystallized grain aspect ratio has been demonstrated from measurement on a sample of calcite mylonites obtained in the footwall of a Proterozoic Nallamalai thrust sheet (Palnad nappe). The relation can be exploited as a kinematic indicator and in tracing low temperature progressive deformation of limestones under non-coaxial strain path and where twinning and dynamic recrystallization are the main controlling factors in fabric development. It has been shown that moderate grain shape modification and dynamic recrystallization do not significantly alter the c-axis pattern evolved through earlier increments of crystal plastic strain.

Dilip Saha and Sukanya Chakraborty

Eastern Ghats orogeny

A crustal scale shear zone at the western margin of the Eastern Ghats belt has been documented with field-structural, microstructural and petrological data. The implication for the craton-mobile belt relation, could be rapid exhumation of the deep crustal rocks in the marginal parts of the Eastern Ghats Orogen, consistent with the model of "extrusion tectonics" by Thompson (2001).

S. Bhattacharya

Discovery of Middle Triassic reptiles and amphibians

In the Satpura Godwana basin of central India, a new fossil site has been discovered in the red mudstone of the Middle Triassic (~ 240 my) Denwa Formation, which is located at the western part of the Satpura basin. This is the first record of fossil vertebrates from the western part of the Satpura basin. Laboratory preparation of a major part of the collections revealed that these bones belong to a rauisuchid reptile, which is a new species and is recorded from the Denwa Formation for the first time. From the adjacent site more fossil bones were recovered recently; the tentative identification of these bones indicates the presence of an erythrosuchid, which was also not recorded earlier from the Denwa Formation.

A new family of a rare temnospondyl amphibian has been identified from the Denwa Formation. The osteology, functional morphology and taxonomy of this new family have been worked out. A similar specimen has earlier been found in the United States in early twentieth century. This is only the second such collection in the world.

A critical review of the theropod dinosaur collection from Late Cretaceous Lameta Formation of Jabalpur was carried out. Several previously described theropods identification and their phylogeny have been revised on the basis of recent findings of new genus and species of theropods from different parts of the world.

In connection with compilation of evolution of fossil vertebrates in India, a thorough analytical study of Indian terrestrial tetrapods spanning nearly 250 m.y. (Late Palaeozoic to Recent / present day) has been done and several serious gaps in the history of terrestrial vertebrates of India were identified.

Saswati Bandyopadhyay and Dhurjati P. Sengupta

Geomorphology and paleoclimate in Satpura upper Gondwana

The Motur Formation has been interpreted as a sandy braided river deposit. While prevalence of red mudstone units with calcareous concretions in the eastern part has been interpreted in terms of arid to semi-arid climate, their absence in the western part is conspicuous. Existence of much larger channels in the western part has been interpreted from bedform and sandbody thickness in the western part. This kind of spatial variation has also been observed in the Bijori Formation. The latter has been identified as a lacustrine delta succession containing several metres thick carbonaceous shale and fine sandstone with large-scale wave and storm generated structures. A well developed paleo-drainage network appears to have been in existence in the western part of Satpura basin. Contrasting geomorphology in different parts of the basin may have been controlled by intrabasinal faults.

S.N. Sarkar, Tapan Chakraborty, Chandan Chakraborty P. Ghosh and P.K. Maulik

Projects

Evolution of the Nallamalai fold belt – fault reactivation and kinematics in an intracratonic fold belt

Early Neoproterozoic convergence of the Eastern Ghats terrane and East Dharwar-Bastar terrane has been proposed on the basis of new structural data from the northeastern Palnad, Cuddapah Basin. It has been shown that the convergence led to thrusting of the Nallamalai rocks over the Kurnool sequence and subsequent development of fold and cleavage under (Neoproterozoic) E-W shortening. Seismic sections have earlier been interpreted to suggest deep and relatively steep faults both along the eastern and western margin of the Nallamalai fold belt. Influence of large top-to-west subhonzontal shear related to the major thrusts which are gently easterly dipping at current erosion level of the foreland like fold-and-thrust belt has been established from new mapping and analysis of kinematic indicators at key localities of the NFB.

Dilip Saha and Sukanya Chakraborty

River Dynamics of the Sub-Himalayan Alluvial Plain in Northeastern India: A Study of Interaction between Tectonics and Climate in a Foreland Setting (A North East Project)

A new project has been undertaken to study the dynamics of rivers flowing through the sub-Himalayan alluvial plain in the north-eastern part of India in the context of flood hazards in this area. A reconnaissance has been done around Guahati and North Bengal. Rapid deforestation of the catchment area and high rate of riverbed aggradation had been observed for a number of major rivers of this area. Several tributary alluvial fan systems (both Recent and Quaternary) have been located in the upstream parts of these rivers. The climatic and tectonic changes of this alluvial plain that govern the dynamic behavior of the rivers can be understood from the study of these fan sediments.

P. Ghosh and Tapan Chakraborty

Tectonic setting of alkaline intrusives : A case study for two such complexes around Rairakhol and Koraput in the Orissa sector of the Eastern Ghats granulite belt (A CSIR Project)

Field-structural and micro-structural data for the Koraput complex, have been analyzed to show that mylonitic shear zone developed in granulitic country rocks at the boundaries of the Koraput alkaline cOomplex. The kinematics of the shear zones has been interpreted. This is compatible in terms of a pull-apart structure that matches the shape of the intrusive body.

S. Bhattacharya

Physico chemical Studies of Self-organised systems using Surfactant(s)/Cosurfactants/Oils(s)/ Polar Solvents (aqueous and non-aqueous)

Rarely reported microemulsions and reverse micelles stabilized by single and mixed surfactants using different oils (of nonconventional type, IPM, plant and hydrocarbon) and water have been formulated. The physicochemical parameters of these novel self-organized systems with respect to phase behaviour, the extent of monophasic zone, stability in different environmental conditions (additives,

temperature), solubilization capacity (of both oil and water), hydrophile-lipophile balance (HLB), mixing ratio of surfactants etc. have been measured. Some novel properties like synergism, temperature insensitivity, three phase body (balanced microemulsion of Winsor III type) etc. have been examined, which bear some significance towards possible applications in various spheres including environmental pollution. The mechanism of solubilization behaviours including thermodynamic parameters, structure and dynamics of these novel microheterogeneous systems have been elucidated, and the role of surfactant type, and component, electrolyte, additives, temperature and oil has been established.

B.K. Paul and Rajib Mitra

Physics and Applied Mathematics Unit

Apart from research activities in Physics & Applied Mathematics, Scientists of this Unit are engaged in teaching various courses like B. Stat (Hons.), M. Tech. (CS), M. Tech (QROR)-II and ISEC. The Scientists also supervise research students enrolled in Ph. D. programme.

Research and other scientific activities

Physics

Condensed Matter Physics :

An alternative mechanism of high temperature superconductivity from the viewpoint of quantum field theory where Berry phase plays an important role has been proposed. In this topological framework each charge carrier is dressed with a magnetic flux quantum and represents a skyrmion. The skyrmion-skyrmion bound state leads to the d-wave Cooper pair formation. The enhancement of antiferromagnetic correlation along with the pseudogap in the underdoped region has also been explained.

Another interesting condensed matter system, quantum Hall skyrmions were studied in the framework of O(4) non linear sigma model . The Magnus force on these skyrmions and vortices along with the polarization of different fractional quantum Hall (FQH) states have been studied. These states have also been studied in the formalism of noncommutative geometry. It has been shown that there exists a dual relationship between the noncommutative field theory realized through the star product of U(1) gauge fields and the deformation of symplectic structure in the noncommutative manifold $M_4 \times Z_N$

B. Basu

Classical Optics

Work on "understanding the most essential features of particle size distribution in the extinction spectrum through numerical experiments" has been completed. Many interesting results have been obtained. This is a collaborative work with Professor S. K. Sharma of S. N. Bose National Centre for Basic Sciences.

A.K. Roy

Foundation of Quantum Mechanics

Set of hazy lumps and probabilistic geometry have been used to understand the physics at Planck scale. The concept of generalized time has been introduced at sub-Planck level so as to understand the space-time at Planck scale. This notion of generalized time has been shown to be related to the concept of time introduced in the framework of sheaf cohomology as proposed by Kato et al. This has important role in understanding non-locality in quantum mechanics from the geometric point of view. Implications in Quantum information and computing are under investigation. This is a collaborative project with Professor M. Requardt (Germany), Professor G. Kato and Professor M. Katatos (USA), and Professor M. Draganescu (Romania).

S. Roy

Dynamic Multiple Scattering and the Shift of the Spectral Lines (DST-Project)

Some experiments have been carried out at NPL, New Delhi, to verify the predictions of the dynamic multiple scattering theory as developed by Roy et al in connection with the shift of spectral lines due to induced correlation in turbulent medium. These results have great significance in astronomy and in cosmological debate. Statistical analysis of the data from quasar emissions has been done to compare with our theoretical predictions. This work was done in collaboration with Professor H. C. Kandpal, Professor R. Mehrortra (NPL, New Delhi), Professor M. Kafatos, Professor J. Gutlory (USA), Dr. S. Datta and Dr. M. Roy (Calcutta).

S. Roy

Brain Function Modeling

The concept of tensor network and functional geometry play significant role in modeling brain function and explaining higher order cognitive activities. The issue of constructing smooth geometric structure and topological properties over the neuro-manifold has been studied. This has very important role in understanding the applicability of quantum concepts in brain function and future researches on artificial intelligence. Collaborators include Professor R. Llinas, Professor Karl Pribram, Professor M. Kafatos (USA) and Professor G. Bernroider (Austria).

S. Roy

Quantum Information and Entanglement

Exact preparation of a d-dimensional quantum state from a special ensemble of states has been carried out at multiple remote locations. This was achieved by a single shot multiparticle measurement, classical communication and the use of dark states as quantum resources. The communication cost involving dark states turned out to be exactly equal to that given by maximally entangled states, thereby making them equally good quantum resources to carry out remote state preparation (RSP). It was also observed that not all dark states were useful for exact RSP. Nevertheless, any superposition of dark states gave rise to exact RSP in a probabilistic manner.

G. Kar and P. Parashar

Quantum Field Theory

Recently Non-Commutative Quantum Field Theory (NCQFT) has emerged as an area of intense activity in High Energy Physics. The NCQFT appears in certain low energy limits of String Theory in the presence of background field, in the Open String boundaries, connected to d-branes. Various NCQFTs in 2+1-dimensions have been studied from different perspectives. Higher dimensional bosonization of NC Thirring model, duality properties of NC Maxwell-Chern-Simons and NC Self-Dual models have been investigated. A novel geometric model, which is inherently noncommutative due to the introduction of spin degrees of freedom, has been formulated. Soliton-like structures appearing in an NC extension of the CP(1) model have been studied. These are distinct from the NC CP(1) solitons so far studied. Similar analysis for the NC extension of the Chern-Simons-Higgs model has been reported. The subtle nature of Lorentz invariance violation in NC gauge theories has been elaborated in the Hamiltonian framework.

S. Ghosh

Quantum Mechanics

A generalised second order intertwining operator has been constructed in the context of Supersymmetric Quantum Mechanics. This has been found to be very useful in obtaining isospectral partners of real (in particular the Natanzon class) as well as PT symmetric potentials. PT symmetric systems with non-Natanzon type potentials and isospectral systems based on excited states have also been studied in detail. Also some important results concerning potentials connected by pseudo supersymmetry have been obtained. Quasi exact solvability of the Dirac equation in the presence of electric fields has also been studied using Lie algebraic as also supersymmetric techniques.

P. Roy, B. Roy and R. Roychoudhury

Theoretical Plasma Physics

Large Amplitude Ion Acoustic Double Layers in Multispecies Relativistic Plasma (Funded by CSIR)

Electron Acoustic Solitary Waves have been studied for a Relativistic Electron beam Plasma system. A new double layer solution has been obtained which was not reported before. Also some exact solutions of cylindrical and spherical dust ion acoustic waves have been obtained.

R. Roychoudhury

High Energy Physics and Heavy Ion Physics

Several aspects of heavy ion collisions at high energies have been studied. A new combinational approach has been built up to explain the extensive data-sets obtained from the latest SPS-CERN and RHIC-BNL experiments with impressive success. Besides, some problems related to Cosmic Ray Physics phenomena are also under the purview of the present studies.

S. Bhattacharyya

Interacting Fock Space

The atom-interacting field evolution in the dipole and rotating wave approximation by probability amplitude method in the context of Jaynes and Cummings model have been studied considering only resonance case. Also phase fluctuations of phase operator when the field is in the interacting coherent state have been calculated.

P.K. Das

Fluid Mechanics and Applied Mathematics

Basic Fluid Flows

Industrial fluid mechanical problems are modelled to understand the physical process involved in their respective applications in industry. Coating the microelectronics substrates with ultra thin film is an important matter in microelectronics industry. In this area of research it has been shown that surface tension enhances the thinning at the central region of the spinner. Intial amount of coating fluid does not affect the final coating on the substrate. In polymer extension process it has been found that the thermocapillary surface force drags the liquid film in the same direction as the stretching sheet and a local velocity minimum occurs inside the film.

B.S. Dandapat

Hydrodynamic Stability and Waves

Waves on a thin conducting liquid film flowing down an inclined plane (North-East Project)

Stability characteristics of a thin conducting liquid film flowing down a non-conducting inclined plane under transverse electromagnetic field is studied. A surface evolution equation has been derived using the long-wave approximation. A linear and nonlinear stability analysis of the evolution equation shows that the magnetic field stabilizes the flow whereas the electric field stabilizes or destabilizes the flow depending on its orientation with the flow. It was found that both subcritical instability and supercritical stability are possible in a finite amplitude regime.

B.S. Dandapat and A. Mukhopadhyay

Nonlinear Problems of Laminar & Turbulent Flows

Applying a scaling group of transformations, the problems on flow of viscoelastic fluid caused by a stretching sheet, viscous incompressible flow of a Newtonian fluid past a flat plate and flow of a power-law fluid in a convergent channel have been worked out. Investigations have also been carried out on

problems of turbulent boundary layer in flows through channel, pipe and in freely decaying homogeneous turbulent flows and some turbulent two-phase flows within the similarity framework. Group-theoretic methods have been applied to some homogeneous turbulent flows and to some problems of dynamical systems.

H.P. Mazumdar

Water waves, Integral equations

Water wave scattering by bottom deformation in ocean with an ice cover, ring source potentials in ice-coverd water and wave diffraction by surface discontinuities have been investigated. The wave diffraction problems require the use of Carleman type singular integral equations leading to solving Rieman Hilbert problems.

B.N. Mandal

Interdisciplinary Research

Flume laboratory (Sedimentological fluid dynamics – interdisciplinary research in collaboration with Mathematicians, Statisticians and Geologists):

Interactions of flow and sediment suspension over bedform structures : experimental and theoretical studies.

Measurements of all three components of mean velocity and turbulent characteristics in an open channel flow of constant depth over an artificial wave form structure had been performed using 3-D Micro-Acoustic Doppler Velocimeter (Micro-ADV) at the ISI flume. The primary motivation of this test has been to identify the spatial changes of flow events due to artificial waveform, which are responsible for the process of sediment upliftment, grain sorting and transportation.

B.S. Mazumder

Turbulent and incipient suspension of particles due to bursting and their sedimentological implications- an experimental study (Funded by DST)

Experiments with flat sand bed of uniform size at the ISI flume were performed to develop the patterns and evolution of bed form structures; and to investigate the spatial and temporal changes of bed forms while they pass over the fixed symmetric waveforms under known flow conditions. The images of bedform structures were collected using the High Speed Camera (500fps). Data collected for turbulent flow characteristics and images of bed form structures are being processed.

B.S. Mazumder

Environmental Diffusion

Investigations on stream-wise dispersion of suspended fine particles with settling velocities released in oscillatory turbulent shear flow with or without a non-zero mean, employing the models for time-invariant and time-varying turbulent eddy diffusivity, have been carried out. The numerical results show that the time-varying eddy diffusivity has a finite effect on the dispersion coefficient. The motivation of this study is mainly to understand the dispersion of suspended particles in estuaries or tidal basin, which is much more complex process.

B.S. Mazumder

Multivariable system and Control theory

Numerical methods for analysis, design and development of multivariable control systems have been developed. An attempt has been made to design observer for matrix second order system.

S. Gangopadhyay

Biological Sciences Division

Agricultural Sciences Unit

Research and Other Scientific Activities

Studies on sustainability criteria in rainfed eastern plateau area

To develop subsistence farming in risk prone fragile ecosystem low input technologies well suited to weather-soil-crop variables and having potential towards contributing to productivity and stability were evaluated and transferred to the farmers. Field trails carried out during the year 2003-04 established supremacy of application of 40 kg N through chemical fertilizer along with 20 kg N through vermicompost over control and 60 kg N through chemical fertilizer alone on rice – based cropping system. A similar trend was observed in winter crops–rice systems. Best result was noted when vermicompost was applied in three splits: at maximum tillering stage; at flowering stage and at dough stage. The improved nutrient management technologies which were already tested at experimental farm were diffused to farmers' field through 'on farm' trials. In the year under review experiments have been conducted on farmers' plots in 10 villages of Giridih district. The results obtained from the farmers' plots also confirmed our experimental findings.

D.K. Bagchi, P.Banik, P.K. Ghosal, B. K. Sarkar, T.Sasmal
and J. Chattopadhyay (Embryology Research Unit)

Rice area characterization using satellite imagery and geographical information system tools

Studies were conducted to minimize the uncertainties associated with rice farming and to induce sustainability in rice agriculture in the region. Rice area characterization was done using GIS and Remote Sensing tools and appropriate time and space for rice cultivation was thereby identified that will increase the productivity. The work has been completed and report submitted. Some of the salient findings of this work are that the south eastern part of the plateau (Purulia) is moderately affected whereas the south western part (Giridih) is severely affected by drought. Uplands and mid uplands are not at all suitable for any types of rice. In the medium land situation, short to medium duration rice should be encouraged. In the lowlands HYV/improved long duration rice varieties can be grown with minimum risk. Rice can be grown in Purulia and southern part of Giridih upto 38 standard meteorological week.

P. Banik, R.N. Das, P.K. Ghosal, S. Das, T. Sasmal
and T. Samanta (Applied Statistics Unit)

Ecology and physiological studies on the mangroves of Sundarbans

Mangroves are specialized woody halophytic economically important plants, which grow in the littoral zones of the tropical world. The vegetational pattern of Sundarbans changes dramatically from the shallow region to the upland portion of an island. Recently it has been found that some important tree species of mangroves 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 these, certain physiological, biochemical and ecological investigations have been carried out on some true mangroves from the Sundarbans to find out their community structure and biomass production, and adaptive status against salt stress.

M. Ghose, S. Das, K. Bhattacharya, P. Nandy, H. Joshi, A. Choudhury
and S. Bandopadhyay (Applied Statistics Unit)

Studies on the ecology, conservation, propagation, and utilization of palms with special reference to rattans (North East Project)

The largest genus *Calamus* of rattan palms has 52 species in Indian flora. Northeast Himalayas is a major centre of their distribution. The other rattan palms are *Karthalsia, Daemonorops* and *Plectocomia*. These palms form one of the most important Non Timber Forest Products (NTFP). Commercially they play an important role in the socio-economy of forest dwelling communities. However, the cane species, of which the golla (*Daemonorops*) is endemic to the northeastern region, are becoming increasingly rare due to unsustainable extraction and destruction of habitat. In view of these, an extensive study on propagation, cultivation, growth behaviour and economic qualities of canes has been initiated at Silchar, Assam in collaboration with Assam University.

M. Ghose, S. Das, and K. Bhattacharya

Anthropology and Human Genetics Unit

Research and Other Scientific Activities

Genetics of dermal ridges

Complex segregation analysis of quantitative dermatoglyphic traits based on factors from principal components analysis was carried out on 500 pedigrees from 5 ethnically and geographically different populations of West Bengal. The results confirmed that a major gene model of Mendelian inheritance with two co-dominant alleles was the most parsimonious model.

B. Karmakar

Effects of Ethnicity and Environment on Health

This project aims to evaluate the effects of ethnicity and life-styles on health in populations inhabiting diverse ecozones. Data on various social, anthropometric, demographic and clinical parameters have been collected from individuals belonging to 114 households of two populations inhabiting a mountain eco-niche (Sikkim) and 573 households inhabiting a coastal eco-niche (Orissa).

S. Mukhopadhyay, S.K. Roy, B. Mukhopadhyay, P. Bharati and R. Gupta

Genomic Diversity in Arunachal Pradesh

Populations which are relatively remote and unacculturated (such as, the *Adi* tribals of Arunachal Pradesh) are of special importance for genetic studies since they provide an opportunity to investigate microevolutionary processes. The Adi tribal cluster consisting of at least ten tribes shows differences in culture, geographic distribution, history of migration etc. About 200 blood samples, collected from seven villages, for 15 autosomal loci have shown that these tribes have low values of average heterozygosity when compared with other Mongoloid tribes of the northeast.

T.S. Vasulu

Genes, Environment and Oral Cancer

Investigation on the risk of tobacco induced oral cavity precancer and cancer in respect of polymorphisms in different drug metabolizing GST genes has been conducted. It is found that polymorphisms in different GST genes enhance the risk of cancer differentially in tobacco users.

B. Roy

Genetic Reconstruction of Peopling of India

Genetic evidence of Austro-Asiatic tribals possessing characteristics indicative of their being the most ancient inhabitants has been provided. It is also shown that the northeast may have served as a major corridor for peopling of India. Further, genetic evidence to support that speakers of Dravidian languages may have been widespread throughout India before the entry of the speakers of Indo-European languages has been provided.

Partha P. Majumder in collaboration with a large number of researchers from various universities and institutions.

Statistical Genetics

The time to the most common ancestor (TMRCA) is an important parameter in population genetics. It has been shown that the current statistical methods of estimation of this parameter are highly biased under many common demographic scenarios. Various probabilistic search algorithms for identification of polymorphic motifs from DNA sequence data have been proposed.

Partha P. Majumder and his collaborators

Biochemistry Unit

Research and Other Scientific Activities

Cervical Neoplasia: Host Genetic Factors for High Risk HPV-Infection

Many women are exposed to high-risk HPV (major etiologic factor of cervical cancer) during their lifetime But only a fraction of infected individuals develop cervical cancer after a long latent period, indicating that the genetic background of the host influences the persistence of HPV infection with the onset of cervical cancer. Some of these host factors are HLA polymorphism, p53 polymorphism etc. Study on both factors revealed the former to be associated with HPV infection and cervical cancer while the latter appeared to be associated with cervical cancer only.

S. Sengupta

HPV infection and Cervical Cancer in the Northeastern States of Manipur & Sikkim (North East Project)

HPV infection and its relation to cervical neoplasia in Manipur have been studied. HPV infection was found to be significantly associated with premalignant lesions as well as CaCx with increased risk for the latter, in this population. Although HPV18 was more prevalent in the population than HPV16, the risk of the latter type however was much higher for development of CaCx and to a lesser extent for premalignant lesions. In Sikkim, 14.7 % HPV infection has been found among the normal women. This was reasonably high, compared to 7.4% in Manipur and other states of India. The trend of HPV infection was found to increase with increase in age of the subjects both in Manipur and Sikkim.

S. Sengupta

Biometry Research Unit

Research and Other Scientific Activities

Studies on Hepatoprotective activity of neem (Azadirachta Indica) leaves

Neem has great reputation in Ayurvedic medicine for treatment of liver disorders and some people use the juice of neem leaves to combat liver disorders. But no systematic investigations have so far been reported regarding its action on liver.

In spite of tremendous strides in modern medicine there are hardly any drugs that stimulate liver functions, offer protection to the liver from damage or help regeneration of hepatic cells. There are however, a number of drugs employed in traditional system of medicine for liver affections. Many formulations containing herbal extracts are sold on the Indian market for treatment of various liver disorders.But management of liver disorders by a simple and precise herbal drug is still an intriguing problem.

A study was undertaken for a systematic probe to find the actual involvement of neem as a hepatoprotective agent and chemical constituents responsible for this activity and possible mechanism behind this action.

The leaf extract/paracetamol/saline were given with the help of feeding cannula. Three groups (Group I, Group II and Group III) of rats with six rats in each group were taken. The leaf extract at a fixed dose (500 mg/kg, p.o.) which was found to be the working dose in our previous experiments, was fed daily for 7 days to one group (Group III) of rats and paracetamol (2g/kg, p.o.) was administered on 5th day after 5th administration of the leaf extract. The normal control group (Group I) and the paracetamol treated group (Group II) received normal saline in place of leaf extract. After 48h of paracetamol feeding rats were sacrificed by cervical dislocation for estimation of blood glutathione, liver glutathione, liver Na+K+-ATPase activity and liver thiobarbuturic acid reactive substances and antioxidant enzymes activity using standard methods.

It was interesting to observe that the concentration of GSH in animals treated with paracetamol was significantly reduced in homogenate of liver and so was the level of glutathione in blood and Na+K+ ATPase level as compared with saline control animals.While thiobarbuturic acid reactive substances of paracetamol treated animals was significantly higher than the saline treated control animals.

Administration of neem leaf extract increased the concentration of GSH in liver and glutathione in blood and liver Na+K+ -ATPase activity significantly when compared to its paracetamol treated control group. On the other hand, the increased level of liver thiobarbuturic acid reactive substances of paracetamol treated animals was significantly reduced in group of animals receiving both neem leaf extract and paracetamol.

Thus, it can be speculated that neem leaf extract is a promising hepatoprotective agent and the hepatoprotective activity of neem leaf extract may be due to its antioxidant and normalizabon of impaired membrane function activity. If followed further, the study may yield an effective drug, indigenous and inexpensive for the treatment of liver ailments.

R.R. Chattopadhyay

Chemistry Unit

Research and Other Scientific Activities

Status and Level of Molybdenum (Micronutrient) in Coastal Saline Soils of West Bengal

Micronutrients are normally present in the soil in an oxidized form. Molybdenum is regarded as a micronutrient for its involvement in the fixation of atmospheric nitrogen and plays a special role as a promoter of growth and development of leguminous crops. This increases not only yields but also protein content. Molybdenum also acts as an agent improving the uptake of soil-derived nitrogen.

The quantity of water soluble forms of molybdenum increases with decreasing acidity of the soil. The coastal saline soils in Canning, Bakkhali, Dutterchak, Nikarighata, Tulsighata and Nalgarh located in the district of 24 Parganas (South), West Bengal were considered for analysis which led to the findings mentioned above.

The assessment of total and available amount of Molybdenum in soils were studied spectrophotometrically at 470 nm wave length, pH and cation exchange capacity in the laboratory.

Results obtained from the investigation showed that the total molybdenum in soils ranged from 1.08ppm whereas plant available micronutrient varied from 0.27ppm-0.34ppm. The soils in this region were acidic with pH value ranging from 5.35-6.62 and the cation exchange capacity was high at 14.9meq/ 100gm.

S. K. Bhattacharyya

Embryology Research Unit

Research and Other Scientific Activities

Mathematical Models on Ecology and Epidemiology

Quantitative ecological studies to establish *in situ* impacts of harmful algal species and their blooms are a high priority of research, now a days. The blooms which impair or disrupt "equilibrium" trophodynamics and whether they fall within the variance in natural catastrophic events which shape the equilibrium need special investigation. From the field collected samples from Digha-Talsari-Sankarpur region of Coastal West Bengal and Orissa, it was observed that there was high abundance of zooplankton populations and less amount of Toxin producing plankton (TPP) in the collection zones nearer to the riverside. But the situation was reverse in the collection zones farther from the riverside. A nontoxic phytoplankton, toxic phytoplankton and zooplankton model has been proposed based on the real life observations. Our results indicate that occurrence of toxin producing phytoplankton may not always be harmful but it may help to maintain the stable equilibrium in trophodynamics through coexistence of all the species. Moreover, the effect of nutrients and other hydrological parameters in this context have also been observed. Introducing the effect of TPP in a tri-trophic food chain model, we concluded that chaotic behavior is less likely in a real food chain dynamics.

J. Chattopadhyay

Plant Chemistry Unit

Research and Other Scientific Activities :

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

The disposal and management of various solid wastes is an ever-increasing problem, both financially and environmentally. Composting is one of the oldest and simplest methods for organic waste stabilization. It is a self-heating biological conservation, which generates a stable product, high in nutrients, which are easily accessed by plants or substrates for mushroom and biogas. The active component mediating the biodegradation process is the resident microbial communities. The optimization of compost quality is directly linked to composition and succession of microbial communities in the composting process. Our understanding of microbial diversity and species composition of microbial communities is hampered by the inability to cultivate and classify microorganisms. Microbial classification based on physiological and biochemical features is often not possible because an estimated 99% of the microbes can not be isolated. The advent of PCR (Polymerase Chain Reaction) has revolutionized microbial ecological studies. It amplifies 16S rDNA, a phylogenetic marker, which is helpful in the identification of microbes. Composting was done by 3 different methods: (1) in pits, (2) in earthen pots and (3) by piling or heaping.

Some of the compost samples collected were fixed with paraformaldehyde. A smear was made on a gelatin coated slide. The smear was hybridized with fluorescence tagged oligo-nucleotide probe of *Thermus*. The smear was counter stained by DAPI and observed under epifluorescence microscope.

S. Chanda, S. Sarkar, P. Mazumdar and S. Barik

Ponds, aquatic weeds and water quality : an investigative study.

The study explores the causes of phytoplankton dominance/disappearance and/or macrophyte dominance/disappearance in small water bodies like ponds, which are widely used by people for various anthropogenic purposes.

The data collected at the end of one year indicate that the phytoplankton-dominated ponds had more phosphorus, total kjeldahl nitrogen and cholorophyll-*a* values and lower Secchi depth visibility

compared to the macrophyte dominated ponds. The species number in the macrophyte dominated ponds varied from 3 to 7 while the blooms in the phytoplankton dominated ponds comprised mainly blue green and green algae.

A. Dewanji, G. Mukhopadhyay and S. Sengupta

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

The Pune-based multinational seed Co. "SYNGENTA" has conducted field trials on new Swedish sugar beet varieties at Pune during the past 5 years. Results from these trials indicated that three varieties are photo-thermo insensitive and can be grown round the year. The crop yields are 60-80 tonnes of sugar beet per hectare in duration of 5-6 months depending upon the season. From one hectare field sugar beet crop yield was estimated as approximately 60-80 tonnes, which ultimately yields 9-10 tonnes of sugar or 6000-7000 litres of Ethanol. Ethanol can be distilled from the beet juice and pulp through solid state fermentation. In India Vasantdada Sugar Institute, Pune and the SYNGENTA seed Company have undertaken a collaborative programme to explore the possibility of introducing sugar beet in the sugar cane based cropping system for sugar and ethanol production. Thus the present study will focus on the new varieties namely HI 0064, Dorotea and Posada which are supplied by "SNGENTA India Ltd". Yield data collection is going on. Till date the performance of new varieties namely Posada, Dorotea, HI 0064 are quite encouraging, particularly in total sugar yield. The study will continue to investigate the following :

a) Fertilizer requirements for optimum root yields;
b) variation in sugar concentration for different varieties at different growth stages and correlation with fertilizer use;
c) ethanol production in laboratory scale for different varieties;
d) find out the optimum harvesting time by which maximum sugar yield can be obtained for ethanol production; and
e) transfer of technology from experimental field to farmer's fields.

S. Bank and S. Chanda

Social Sciences Division

Economic Research Unit

The scientists of ERU have been teaching various courses in economics and econometrics for the B.Stat. (Hons.), M.Stat., ISEC (regular and specialization) and M.S.(Q.E) programmes. Six research fellows are currently working for their Ph.D. under supervision of members of the faculty of ERU.

Research and Other Scientific Activities

During the past year the Economic Research Unit has undertaken both theoretical and empirical research. The theoretical research includes topics in :

Industrial Organization

Multinational companies, Technology transfer, Mergers, Joint ventures, Intellectual property rights, Research and Development

Tarun Kabiraj and Uday Bhanu Sinha

Cooperative Game Theory (Voting game)

Satya R. Chakravarty

Welfare Economics (Welfare orderings; Measurement of inequality and multidimensional poverty)

Satya R. Chakravarty

International Trade (International trade under monopolistic competition; Trade and wage inequality)

Brati Sankar Chakraborty

Mechanism Design Problems (Allotment problems, Scheduling problems, Regulation)
Manipushpak Mitra

Political Economy (Optimal Assembly size)
Manipushpak Mitra

Endogenous Growth Theory (Productive consumption and Endogenous growth; Human capital accumulation and dualism; Long run growth and received theory, Growth in private and command economies, Technical progress; Uncertainty and economic growth)
Dipankar Dasgupta and Manash Ranjan Gupta

Macroeconomics (Issues on Indian economy: Economic liberalization, Macroeconomic policies)
Chandana Ghosh

Econometric Methods (Effect of extreme observations and Errors in Variables in Frontier Production Function; Modelling of non sampling errors in survey)
Manoranjan Pal, Chiranjib Neogi, Buddhadeb Ghosh and Pulakesh Maiti

Environmental Economics (Economic instruments for pollution control)
Pradip Maiti

The empirical research areas are:

Welfare and Development Economics (Human development; Standard of living and Poverty; Gender inequality and deprivation; Infrastructure and economic development)
Dipankor Coondoo, Amita Majumder, Krishna Mazumder, Diganta Mukherjee, Manoranjan Pal and Buddhadeb Ghosh

Applied Financial Economics (Econometric and Time series Analysis of Indian bond and money market)
Dipankor Coondoo

Financial econometrics (Predictability of returns; Testing market efficiency, and Finding causes of market inefficiency; Nonlinearities in financial data; Role of Central Bank in foreign exchange market)
Nityananda Sarkar

Environmental Economics (Solid waste management; Eco-tourism; Impact assessment, Water resource management, Forestry; Non-conventional energy source; Awareness about environmental pollution; Effect of growth and development on environment)
Dipankor Coondoo, Snigdha Chakrabarti, Subhendu Chakrabarti, Kunal Chattopadhyay, Krishna Mazumdar and Pradip Maiti

Index Numbers (Regional consumer Price Indices from household level data; Nutrient Prices from household level food expenditure data; Composite indices of well being/ standard of living)
Dipankor Coondoo, Amita Majumder and Krishna Mazumdar

Industrial Economics (Measuring technical efficiency; Impact of liberalization on Small Scale Industries)
Chiranjib Neogi and Buddhadeb Ghosh

Agricultural Economics (Welfare aspects of agricultural growth in India; Agrarian institutions; Price formation in agricultural markets)
Manabendu Chattopadhyay, Abhirup Sarkar and Sandip Mitra

Macroeconomics (Income distribution and inflationary process; Trade-off between employment and output growth, Determinants of well-being)
Arun K. Sengupta and Krishna Mazumdar

Health Economics (Relationship between standard of living and health)

Sandip Mitra and Krishna Mazumdar

Economics of Education

Krishna Mazumdar

Public Finance (Tax performance, Taxable capacity and debt problems of states in India)

Dipankor Coondoo, Amita Majumder and Chiranjib Neogi

Globalization (Convergence/ Divergence of standard of living; Economic growth and productivity; Effect of globalization on inequality, poverty, growth and literacy; Asian Economic Cooperation: Trade and transaction cost)

Krishna Mazumdar, Buddhadeb Ghosh and Manoranjan Pal

Several projects have been undertaken during the past year. Apart from the externally funded projects the Unit has undertaken three plan projects, of which two are workshops/conferences. Two of the plan projects are related to the North-Eastern region of India.

Externally funded project

Environmental Management Capacity Building Assistance Project: Environmental Economics Component

A project of five years' duration, undertaken by the Ministry of Environment and Forests, Govt. of India, with assistance from the International Development Association of the World Bank, was completed in June 2003. Under this project a number of training programmes, workshops and seminars were organised. The project has helped improve the infrastructural facilities and has also enriched the library. The project 'Solid Waste Management in Baranagar Municipal area', that was undertaken as a part of this bigger project, has been completed. The report writing is under way.

Study about the Steel Sector (Medium and Small Scale) Units

The project was undertaken in response to a request from the West Bengal Financial Corporation (WBFC) to study (i) the present state of units in the Steel Sector financed by the Corporation, (ii) the prospect of further exposure by the Corporation in the Steel Sector; and (iii) the market prospects for such products in the region. The report has been submitted in September 2003.

Workshop on '**Quantitative Analysis of North East Indian Economy**' was organised in collaboration with the Department of Economics, North Eastern Hill University (NEHU) during 8-13 March, 2004. The purpose of this plan project was to have an exchange of ideas between academicians of the Indian Statistical Institute and the North-East Indian Universities regarding the economic problems of North-East India and application of relevant quantitative techniques to analyze them. Twenty one workshop participants were selected from Research Scholars/Faculty members in Economics of under-graduate colleges and universities of North-East India. Of them, nineteen turned up from colleges/universities of Aizawl, Darrang, Dibrugarh, Goalpara, Golaghat, Guwahati, Imphal, Shillong, Silchar, Tura and Umsning. The topics covered in the workshop were Microeconomics, Macroeconomics, Econometric Methods and Applications and Time Series Analysis. The workshop turned out to be a success and the response from the participants was overwhelming.

A '**Conference on Models and Methods in Economics**' was held during 15-17 January, 2004, as part of a project in its third year. The conference was well attended and speakers from all over the country participated in the conference.

The plan project '**Study on some Health Economic Issues in the North East**', which started in April 2003, has the following main objectives : (i) To understand the health and sanitation facilities available to the Khasi and Naga tribes of Meghalay and Nagaland, (ii) To examine their ability to avail such

facilities, (iii) To find out the access to private health care system and (iv) To examine the coverage of health insurance schemes among these tribes and to suggest some policy prescriptions. So far data collection, computerization, partial tabulation and analysis have been done.

Economic Analysis Unit

Research Activities

The unit is actively 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, applied computable general equilibrium models and growth and inflation are of current interest.

Research in transfer pricing, inventory-models under production smoothing hypotheses and variance-bound tests, intervention analysis and transfer function analysis and VAR models is being pursued by the research scholars of the unit.

N.S.S. Narayana

Two senior research fellows are working for their Ph.D in the unit. The unit conducted training programmes on 'Economic Planning' for five trainees of International Statistical Education Centre (ISEC) and on 'Econometrics, Time Series and Forecasting Techniques' for eight probationary officers of the Indian Statistical Service (ISS).

Planning Unit

Research and Other Scientific Activities

The faculty participated in the teaching of Master of Science in Quantitative Economics (MSQE) programme.

A four week training program was conducted for ISS Probationers in Macroeconomics, microeconomics and Economic Development in September 2003. A three day training program was conducted in December 2003 for ISS officers.

Members of the Planning Unit carried on a wide range of research activities. Some of the areas in which research was undertaken are : i) Impact evaluation of primary school education in India, (ii) Water filtration Methods in Gurgaon city, iii) Vulnerability estimates for Indonesia, iv) Credit Markets, Loan Contracts and Household Poverty: A Study of Self Help Groups in the State of Jharkhand (jointly with Jean Marie Baland, University of Namur and Isha Dewan, ISI Delhi), v) Measuring Deviations from Optimality in Allocations of Public Amenities Across Villages in India (jointly with Siva Athreya, ISI Delhi), vi) Peers and Hierarchies: A Study of Labor Productivity in the Indian Steel Industry (jointly with Sanghamitra Das, ISI, Delhi), vii) Theoretical and empirical analysis of the difference in performance levels of private and cooperative plants in the Indian sugar industry, viii) Theoretical and empirical work on the link between poverty, local governance and deforestation in Uttar Pradesh and Himachal Pradesh, ix) Macroeconomicss, x) Political Economy, xi) Public Finance, xii) Mechanism Design, xiii) Auction Theory, xiv) Voting Theory, xv) Game Thory, xvi) Industrial Organization, xvii) Development Economics, xviii) Corporate Finance, xix) Risk and Insurance and xx) Food Policy.

Endogenous Distribution, Politics and Growth

This work develops a framework in which the long-run wealth and income distribution in a market economy is 'endogenous' in the sense that it is independent of initial distribution. Long run growth is also endogenous, via provision of a public input financed by tax on income or capital. In contrast to the existing literature it shows that policies that bring in more equity do not necessarily improve long

run growth. If a redistributive policy goes towards financing a productive input then it enhances growth as well as equity. But if it is primarily redistributive, it hurts long run growth. In other words, running a 'welfare state' is not conducive to growth.

Satya P. Das and Chetan Ghate

Trade Policy and Distribution of Income and Wealth

One part of the research examines the issue of free trade and relative wages. It recognizes that producing 'quality' of a good is more skilled-labor intensive than producing 'quantity'. This implies that free trade between skilled labour abundant developed countries and unskilled labour abundant developing countries may increase the skill premium in both groups of countries.

Another part builds an agglomeration type model of 'North-South' trade. Instead of comparing autarky to free trade, it examines how gradual liberalization may affect inequality of income within and between countries. There is a working paper, "Gradual Liberalization and Inequality within and between Countries".

International Trade, by changing relative prices of goods, changes relative reward to skilled and unskilled labor. In turn, this influences decision to acquire skill. The paper models this process and wealth distribution in an economy. It is shown that free trade between developed and developing countries worsens income distribution in the developed countries but improves it in developing countries. However, financial liberalization may have opposite effects.

Satya P. Das

Inequality and Segregation

Despite declining group inequality and the rapid expansion of the black middle class in the United States, major urban centers with significant black populations continue to exhibit extreme racial separation. Using a theoretical framework in which individuals care about both the affluence and the racial composition of neighborhoods, we show that lower inequality is consistent with extreme and even rising levels of segregation in cities where the minority population is large. Our results can help explain why segregation continues to characterize the urban landscape even though survey evidence suggests that individuals favor more integration than they did in the past.

R.Somanathan and R. Sethi, Barnard College, Columbia University

The political economy of public goods: Some evidence from India

This paper examines how public goods get allocated by a centralized state. We use data on social structure and public goods in rural india over the sixties, seventies and eighties to examine the influence of particular social groups, and of social and economic heterogeneity more generally, on the availability of public goods. This was a period of rapid expansion in these goods and of important shifts in the political leverage enjoyed by different groups. We find that social divisions are important, but so are the relative positions of particular groups in the broader social hierarchy. These divisions are not however immutable, nor is their influence overwhelming. Some previously marginalized communities have gained over this period while others continue to be disadvantaged. There has also been considerable convergence in the availability of public goods over this period, suggesting that the state feels some compulsion to equalize access, even to those who are not politically influential.

R. Somanathan and A. Banerjee, Department of Economics, MIT

Patronage in Public Administration: Presidential Connections, Position Assignments and the Performance of Korean Public Prosecutors, 1992-2000

Presidential elections in Korea in the eighties and nineties provide an opportunity to examine the role of political patronage in a newly formed democracy. We examine whether the bureaucratic reshuffling which accompanies presidential changes depends on the political connections of bureaucrats and whether bureaucratic reassignment is associated with changes in administrative performance. We use data on all public prosecutors in Korea between 1992-2000 and find that sharing birth and school environments with the incumbent president roughly doubled the odds of being assigned to a range of

influential positions within the Public Prosecutor's Office. In the last of the three presidential regimes we consider, we also find that branch offices with high fractions of connected prosecutors performed poorly relative to other branches. Observations over multiple years allow us to control for unobservable characteristics of prosecutors and offices while estimating these effects of political patronage.

R. Somanathan and No-Wook Park, Korea Institute of Public Finance

Ownership Form and Contractual Efficiency: Comparing Performance of Cooperatives and Private Factories in the Indian Sugar Industry

The key incentive problem is that factory owners are inclined to exploit their monopsony power and underprice cane supplied by farmers. This results in undersupply of cane to factories, the extent of which depends on who owns the factory. We find that the respective cane price distortions overwhelm the effect of changes in cane quality, technological change, prices or irrigation in accounting for differences in growth of the industry between different ownership forms and regions over this period.

S.Das and Dilip Mookherjee (Boston University)

Poverty, Local Governance and Deforestation in Uttaranchal and Himachal

A three-year long primary data compilation on 165 villages and about 4000 households was completed with the purpose of examining the view that assigns poverty a key role for 'over-consuming' common resources such as forests leading to environmental degradation. In the data we find that (1) almost all households collect firewood, (2) all forms of local governance seem to be decaying with greater commercialization and (3) informal institutions are more effective than formal ones initiated by the govt. Currently, interactions of all these factors are being modeled before it is econometrically estimated.

P. Bardhan (U.C. Berkeley), Jean-Marie Baland (U. of Namur),
S.Das, Dilip Mookherjee and Rinki Sarkar,

Impact of decentralised community management on forest conservation in the Himalayas

The work is nearing completion. Research for a book on environmental problems in India continues. Some working papers are available for download from the Planning Unit home page.

Valuing Lives Equally: Distributional Weights for Welfare Analysis

Cost-benefit analysis as performed by governments and public-sector organisations typically applies equal weights to changes in incomes accruing to individuals from projects even when there is no proposal to compensate losers. One reason for the use of equal weights despite the absence of a theoretical justification for this practice is that all weights appear arbitrary. This note proposes the use of weights based on two axioms: (1) that all lives should be equally valued, and (2) that the monetary value attached to a person's life should be his or her own. This implies weights that are proportional to the reciprocals of the values of statistical lives.

E. Somanathan

Awareness and the Demand for Environmental Quality: Drinking Water in Urban India

The demand for environmental quality is often presumed to be low in developing countries due to poverty. Less attention has been paid to the possibility that lack of awareness about the adverse health effects of environmental pollution could also keep the demand low. We use a household survey from urban India to estimate the effects of awareness and wealth on home water purification. Average costs of different home purification methods are used to get estimates of lower bounds on willingness to pay for better drinking water quality in Delhi. We find that measures of awareness such as schooling and exposure to mass media have statistically significant effects on adoption of different home purification methods and therefore, on willingness to pay. These effects are similar in magnitude to the wealth effects.

Jyotsna Jalan, E.Somanathan and Saraswata Chaudhuri

Being Informed Matters: Experimental Evidence on the Demand for Environmental Quality.

A randomly selected treatment group of households in Gurgaon was informed whether (or not) their drinking water had tested positive for fecal contamination using a simple test costing about $0.50. Households that were not initially purifying their water, and were told that their drinking water had tested positive, were 11 percentage points (p-value < 0.01) more likely to begin some form of home purification in the next 7 weeks than households in the control group that received no information. This effect raised the mean purification expenditure in the sample by 10 percent. By way of comparison, an additional year of schooling of the most educated person in the household, raises the probability of (initial) purification by 4.4 percentage points while a move from one wealth quartile to the next raises it by 15 percentage points. Households that received a negative test result were not significantly different in their behavior from control households. Gurgaon is considerably wealthier than the average Indian city, yet awareness about the causes of diarrhoea is low.

Jyotsna Jalan and E. Somanathan

Collective Action in the Commons: A Theoretical Framework for Empirical Research

A model of collective action in the commons that is intended to provide a framework for empirical research into the question of when cooperation is likely to be successful is presented. It is based on the presence of costly punishment opportunities, some players who have a taste for punishing those who violate agreements to cooperate (an assumption strongly supported by recent experimental research), and bounded rationality. It predicts that cooperation is more likely when communication is cheap, the technology of public good provision is sufficiently productive, effective punishment opportunities are available at sufficiently low cost, and when group size is large (holding constant the other parameters mentioned). Heterogeneity in the ability to inflict punishment or be hurt by it may result in collective action becoming infeasible, especially when there are increasing returns to the public good, but there is a range of parameters in which changes in heterogeneity will have no effect and circumstances in which heterogeneity will actually favor cooperation.

Rajiv Sethi and E.Somanathan

Auction Theory

A paper entitled "Incentive Compatibility in Multi-Unit Auctions" was completed. A new condition which is necessary and sufficient for a (deterministic) allocation function to be incentive compatible (in dominant strategies) was identified. This condition is far more transparent than the usual sub-differentiability condition and offers promise for solving problems such as the design of revenue optimal auctions, etc.

Arunava Sen, Sushil Bikhchandani (UCLA) and Shurojit Chatterji (ITAM, Mexico)

Strategic Voting Theory

A paper entitled "Strategy-Proof Cardinal Voting Schemes" was completed. We prove a random dictatorship result in a model where a social choice function can depend on the von-Neumann-Morgenstern utilities for players. We demonstrate a limit result as the maximal utility gap between alternatives goes to zero. Our proof technique also allows us to provide upper bounds on the probability of realizing "non-top" alternatives as a function of the utility grid size.

Arunava Sen, Bhaskar Dutta (University of Warwick) and
Hans Peters (Maastricht University, The Netherlands)

Growth and distribution

This work on models of endogenous distribution in an optimal growth framework attempts to show that the transitional dynamics governing wealth distribution can be characterized in a fairly simple way, something that has so far not been done in the literature. Adding transitional dynamics enables us to understand better the forces that influence income inequality in the short run and long run, as well as its influence on economic growth.

Chetan Ghate

Models of capital market integration, human capital, and optimal growth

The idea here is to formalize whether financial openness affects economic growth by leading to lesser investment in education.

Chetan Ghate and Areendam Chanda (LSU, USA)

Population Studies Unit

Research and Other Scientific Activities

Health Care Practice and HIV/AIDS awareness level among sex workers : a case study in North 24 Parganas.

The objective of this project is to prepare a data base containing information on the nature of Sexually Transmitted Diseases among sex workers and their health consciousness as well as health seeking behavior and the awareness level of HIV/AIDS. From the study it may be concluded that the living and economic conditions of the sex workers are very poor in these localities. More attention should be paid to the direction of their education, living and health care facilities. As stated by the sex workers they get proper treatment and health care facilities neither from hospitals nor from the clinics of the NGOs. They complained that the doctors also do not behave with them generously. Most of them are really very poor and can not buy highly priced medicines. From the hospitals and clinics medicines are available only for nominal diseases, they are never provided with any costly medicine from these sources. Other than these, they should also be more familiarised with the mass media programmes related to family planning and HIV/AIDS and other STDs. Government policies should be implemented in the direction of the protection of the health of the sex workers to save ultimately the whole society from the fatal disorder caused by HIV/AIDS.

Rama Deb Roy, Swagata Gupta, and Partha De

Ascertaining Component-wise intercensal population numbers by symptomatic accounting and related procedures in two districts of Assam.

The aim of this study is two fold : (i) to use easily available suitable auxiliary information to estimate certain parameters relating to population, and (ii) to examine how some of these symptomatic data may be efficiently utilised to derive more accurate estimate of projected population. The symptomatic variables used are : (i) number of students and (ii) the population size. The population size yielded better results in almost all situations in terms of the criterion of " Coefficient of Variation"

Shankar Dihidar, Arijit Choudhury, B.N. Bhattacharya, D.C. Nath

Factors affecting age reporting errors in India through some multivariate statistical analysis

This research tries to find out the various socio-economic and developmental factors and their commonalities in the variation in reporting errors in Indian age data from National Family Health Surveys: (i) NFHS-I, 1992-93 and (ii) NFHS-II, 1998-99.

The backward regression procedure has been employed to select only a few important and significant independent factors for commonality analysis. Literacy appears to be the most important and significant factor in explaining the variation of age reporting errors. Average household size is also a contributing factor for the variation of age reporting errors. Improvement in literacy level and decrease in average household size will definitely improve the quality of age data.

B.K. Mukherjee and P.K. Majumdar

Nepali Female Migration and Trafficking

This study is devoted to highlight the documented and undocumented Nepali female migration to West Bengal. It is revealed that though documented female Nepali migration shows a declining trend, however, undocumented migration for sex work is gradually increasing. Poverty, organised network,

profit accruing to traffickers, demand for fair skinned delicate featured girls, and open border between Nepal and India are responsible for this illegal female migration.

Pranati Datta

Measures of Fertility by ethnicity in Tripura : An application of Bongaart's model with an extension of Stover's correction

By considering fertility inhibiting effects of extent of marriage, practice of contraception and abortions, and period of abstinence/breast-feeding after child birth among women within reproductive ages 15-49, Bongaart's model is used to measure total fecundity of a population and extended further to accommodate correction suggested by Stover. No significant difference is found among tribes and non-tribes in terms of total fecundity, index of contraceptions and abortions, and index of sterility.

P.K. Majumdar

On the proportionate age structure of the population of West Bengal : 1951-91

For the estimation of demographic parameters such as fertility, mortality and migration, population by age is required. However, age data is misrepresented due to misreporting of ages caused by either age heaping or by age shifting or by both. Therefore, it is necessary to smooth age data before estimating demographic parameter from such data. Third degree polynomial and stable population model (Y-transformation) are applied to smooth age data. However, the former appears to be a better fit to the observed age data than the latter for West Bengal (1951-91). Hence, third degree polynomial fit is used to derive an approximately true age distribution for the population of West Bengal.

Anuj Kumar Saha

Female nuptiality in West Bengal and Bangladesh : An Episode

Age at marriage is not symmetrical; it is rather skewed to the right as evidenced from the singulate mean age at marriage (SMAM) and median age at marriage (MAM). The females complete first marriage by age 37 years in West Bengal (NFHS 1992-93) and by age 32 years in Bangladesh (1991). The first marriage frequencies, peak age at first marriage has shifted from lower ages to the higher ages both in West Bengal and in Bangladesh.

Anuj Kumar Saha

Differential in Contraceptive use among Non-tribes and Tribes in Tripura

An attempt is made to understand the extent of use of contraception among Non-tribes and tribes of Tripura and socio-economic factors responsible for the differential use or non-use of contraception among these two population groups through multivariate statistical analysis, especially through Logit Analysis. The analysis indicates that there is no significant differences for the use of contraception among tribes and non-tribes. However, only at four or more living children, tribal group shows significantly lower propensity to use contraception than non-tribes.

P.K. Majumdar

Psychology Research Unit

The faculty members and scientific workers of the Unit are actively involved in research and different project works. Guidance is also being provided by the faculty members to three Senior Research Fellows and one Junior Research Fellow for their Ph.D. works in Psychology in different state Universities.

Research and Other Activities

A study on Short-term memory assessment under successive decrease in stimulus presentation time using computer – aided digit span test

Memorizing digits is an integral part of our everyday life. The present study attempts to explore some determinants of short term memorizing capacity when the stimulus presentation time is successively decreased. This study is important for advertising and mass education through visual display. Preliminary analysis revealed relationship of different stimulus lengths with different memorizing response errors.

Debdulal Dutta Roy and Manjishtha Maitra

A study of Organizational health and Job satisfaction in Rural banks from Psychological perspective

Rural bank plays a pivotal role in improving rural economy. Improving job satisfaction level of rural bank employees develops more intrinsic work motivation. Current study examines how evaluation about different organizational health parameters of rural banks is related to job satisfaction. Results show that this relationship varied across different rural banks.

Debdulal Dutta Roy and Susmita Mukhopadhyay

Entrepreneurial Behaviour

A Socio-psychological Approach for identifying potential Entrepreneur : The objective of this study is to find out some socio-psychological factors which have significant association with entrepreneural success; at the same time, it aims to provide some comprehensive prediction models through which potential entrepreneurs may be identified in an empirical way. This study was conducted on 217 entrepreneurs randomly selected from four districts of West Bengal. Results of this study indicate that variables like individualism, collectivism, task-motivation, locus of control, entrepreneurial status and technical training have significant impact on entrepreneurial success. Obtained prediction model works very efficiently on the entrepreneurs of West Bengal, but it can not work so efficiently on the entrepreneurs studied from Bangalore & Agartala, because of different marketing facilities. Therefore, it has been suggested that one has to develop different prediction models for different market conditions with the help of the selected socio-psychological variables.

Anjali Ghosh and Rachana Chattopadhyay

Self-Construal, Personal Values and Attitude towards Dowry

The study has been conducted on college students of three different sub-cultures of India to find out how self-construal and personal values influence one's attitude towards dowry. Findings indicate that gender and culture have an important role in the formation of attitude towards dowry. Significant differences were also observed on different dimensions of personal values, self-construal with respect to gender and culture.

Anjali Ghosh

Team effectiveness in work setting

The main objective of the study is to find out the internal correlates of team effectiveness. Instruments for data collection have been finalized. Data collection from various work set up is in progress.

Anjali Ghosh and Monika Sharma

Sociological Research Unit

The scientific workers of Sociological Research Unit (SRU) have been teaching Sociology at B. Stat. (Hons.) III year level and selected topics in Economics at MS (QE) II year level. Some of them have continued their teaching assignments in the course on 'Selected Themes in Development Studies' for Junior Research Fellows in SRU during January-May, 2003.

Research Activities

In tune with the recommendations of the Third ISI Review Committee (2002), SRU has been carrying out several internal and external research projects in the following themes which have relevance for understanding various processes of social transformation and comparative development in the

country: (i) agrarian relations and rural development, (ii) decentralization of planning process, iii) evaluation of socio-economic impact of literacy movement, iv) religious and ethnic problems, v) role of outstanding thinkers and institutions in social transformation, and vi) new methodological research for social network analysis by using probabilistic and graph theoretic techniques. These research themes, with empirical thrusts, have been taken up by SRU mostly at head quarters in Kolkata covering West Bengal and partly at Giridih Branch in Jharkhand as well as in Tamil Nadu and Tripura.

Projects

Economic reforms and rural development : a study of agricultural labour in eastern India

The project attempts to study the socio-economic characteristics of the households of agricultural workers, based on village level samples, in different states in eastern India, with special emphasis on financial liberalization and rural credit in India.

Nationalism, modernity and the Indian Statistical Institute (1931-2000)

The objective is to write a history of the Indian Statistical Institute, with a focus on its relationship with the changing life of the Indian nation in respect of modernity, for the decades before and after Indian independence.

Study of social network in some villages in Giridih area in Jharkhand and Md. Bazar area of West Bengal

The objective of this study is to investigate the pattern of social relationship, delineating the influence of factors like higher caste, feudal forces and Panchayati Raj, in the selected villages in Jharkhand and West Bengal.

Appraisal of village resource mapping : case studies in West Bengal

The objective of the project is to evaluate, through participant observation in case studies, the effectiveness of village resource mapping in unleashing the initiative of the people for mapping information required for decentralized planning in the selected villages in two districts of West Bengal – North 24 Parganas and Birbhum. This resource mapping is also expected to provide basic information on the extent of empowerment of the deprived classes in respect of access to, and utilization of land and non-land resources in the selected villages.

Occupational segregation in the factory sector in Indian industries (1961-2001)

The purposes of the project are a) to measure degree of occupational segregation between male and female workers based on various indices in all the States covered by the Annual Survey of Industries, Govt. of India, in the factory sector and over time from 1961 to 2001, and b) to identify the male-dominated occupations and the female-dominated occupations.

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

The project report has been submitted recently. SRU has been requested by Labour Department, Govt. of West Bengal, to undertake a follow-up study.

Study on Status of Women in West Bengal

The comprehensive project report has been submitted.

Statistical Quality Control and Operations Research Division

The Division comprises of SQC-OR (T&P) Unit and Central SQC (CSQC) office located in the main campus at Baranagore, SQC & OR Units at nine other centres - Bangalore, Baroda, Chennai,

Coimbatore, Delhi, Hyderabad, Kolkata City, Mumbai and Pune. The CSQC office functions as the office of the elected Head of the Division and co-ordinates various activities of the Division.

The activities of the division consisted of Research, Academic Teaching, Consultancy and Training. Conducting M.Tech. (QROR) programme at Kolkata and Part-Time Certificate courses at Bangalore and Hyderabad were among the primary responsibilities of the division. The faculty members of the division also taught in various academic programmes like B.Stat., B.Math., M.Stat. and ISEC Regular course. They have also supervised dissertation and project work by M.Stat. and M.Tech.(QROR) students. Baroda unit continued organizing the Correspondence Programme in Statistical process Control.

During the year, the division conducted a Summer School on SPC, a National Conference on Six Sigma, an International Conference on Operations Research and two Industry-ISI Meets. A total of nine seminars/symposiums/workshops and five programmes in the North-East were conducted. Faculty members of the Division attended a number of Conferences/ Seminars and delivered invited talks/lectures.

The faculty members of the division had been engaged in carrying out theoretical and applied research work as well as supervising research scholars for their Ph.D. Currently two of the faculty members are guiding Ph.D. students, five of them are actively pursuing research work at various SQC & OR Units for Ph.D. and one of the members has submitted his thesis for evaluation.

Training and consultancy were other major areas of work for the divisional faculty members. The Division extended its consultancy and training services to over 100 organizations during 2003-2004. The division organized 180 training programmes covering over 3000 participants at various levels – Top management, Sr. Management, Executives / Engineers, Software professionals and supervisory staff. The topics included SPC, Simple Tools, Design of experiments & Taguchi Methods, Six Sigma awareness, Black Belt, Green Belt, QM Systems awareness, Reliability, Quantitative Techniques, Software Metrics etc. Consultancy was provided in problem solving in quality and related areas using quantitative techniques and, in development and Audit of Quality Management Systems. Work in new areas like modelling of brand share prediction for FMCG products, application of quantitative methods in business process outsourcing had been initiated. The industries which benefited from these activities are MICO, Reliance Industries Ltd., KEC, Macmillan, L&T, HP Global e-Business Operations Pvt. Ltd., Grindwell Norton, AT & S India Ltd., Grasim Industries, Britannia Industries Limited, Balmer Lowrie (Project Division), Infosys Technologies Ltd., ITC Limited (ITD Division), Skytech Solutions, Metal and Steel Factory, ACNielsen ORG-MARG to name a few. The division has made a modest beginning in exporting its services overseas. Export of consultancy was provided to Iran, Thailand and Nepal. OS 9000 Audits on behalf of NVTQC, KEMA were conducted in countries like China, Thailand, Indonesia, Philippines and Germany. Faculty members of the division have also participated in collaborative research projects of the Applied Statistics Division.
During the period under review, fourteen papers were published, five papers were accepted for publication, two papers were submitted for publication and fifteen papers were presented in conferences by the faculty members. Three scientists visited the division for collaborative work and for delivering talks/lectures.

A 6-day workshop on 'Application of Computers in Office Management' was organized by CSQC, Kolkata during 14 - 19 October 2003, for the non-scientific workers of SQC & OR division and, for other Divisions and units located in Kolkata.

Areas of Research Activities

Economic Design of Control Charts for Logarithmic Series Distribution, Bayesian Sampling Schemes, Quality Adjusted Lifetime, Software Quality and Metrices, Software Reliability through Non-parametric Smoothing, Neural Network, Fourier Series and Bayesian Methods, Optimum Release time of Software, Consecutive K-out-of-n F System, Reliability of Shared Load Parallel System, Life Distribution, Linear Complementarity Problem (LCP), Semi Definite Linear Complementarity Problem (SDLCP), Non cooperative Games, Stochastic Games, Cooperative Games, Combinatorial Optimization, Modeling of Measurement Process, Design of Experiments, Process Capability Indices

for Non-Normal Distribution, Statistical Modeling of Warranty Cost Analysis, Multivariate Statistical Process Control, Six Sigma and BFSS Breakthrough Strategy, Applied Regression Analysis and Regression Diagnostics.

Fourth International Conference on Operations Research, Kolkata

The 4th International Conference titled "Operations Research with Economic and Industrial Applications (ICOR-2004)" was organized by SQC & OR Unit Delhi jointly with SQC & OR Unit, Kolkata and SQC-OR (T&P) Unit on behalf of the Division during 08 - 10 January 2004. RBI and DST cosponsored it. There were 80 participants including 6 from abroad. In all 85 theoretical papers as well as applications in Finance and Economics, and Industries were presented. Organizations which participated in this conference include Progeon, Tata Steel, Madras Medical College & Govt. Gen. Hospital, Orient Fan, Durgapur Steel Plant, DRDO. A number of participants from different colleges under UGC and from engineering colleges all over India including the Northeast region also participated in this conference.

Industry-ISI Meet, Kolkata

The 'Industry-ISI Meet' was organised jointly by SQC and OR Unit, Kolkata, SQC-OR (T&P) Unit and CSQC at Hyatt Regency, Kolkata during 17-18 November 2003. 44 top executives from major industries, chambers of commerce and important service sectors attended the meet. The presence of industries from Northeast region was a special feature. The aim of the meet was to understand the perception and expectations of industries with respect to the Specialist Development Program and the Quality Mission Project, in particular, and the over all services being provided by the SQC & OR Division, in general. The deliberations highlighted the emerging sector specific need for services of ISI and, the need of ISI as a change agent in the drive for continuous improvement in customer satisfaction and simultaneous reduction of cost. The distinguished panelists also recommended the need for a higher level involvement with ISI in the context of the fast changing customer perception and the growing influence of the service sector in the Indian economy. Specific recommendations and guidelines for reorientation of our services were made while underlining our strength and weakness. A report was submitted to the Director, ISI for necessary action.

Divisional Publications

The Bangalore unit continued publication of the divisional NEWS LETTER and brought out three volumes in the current year.

U. N. Acharya, A. K. Chaudhuri, N. T. V Ranga Rao eds.

The division brought out a special publication titled 'Research and Publication in SQC, OR and Quality Management: 1984-2002'. It provides a list and abstract of about two hundred papers, classified according to the area of work.

A. K. Chakraborty, A. R. Mukhopadhayay, M. Z. Anis, A. K. Das eds.

The details of the activities of different units are given below.

SQC & OR Unit, Bangalore

Teaching and Training:

Faculty assistance was provided for teaching in B.Math. programme at ISI Bangalore centre. Teaching in Part-time Certificate Course in SQC was continued for two new batches during January - June 2003, July – December 2003 and January - June 2004. A total of 10, 13 and 19 students were admitted in the respective batches.

Other Scientific Activities

Academic consultation and consultancy services was extended to 24 industries/organizations during the year 2003 -'04. A total of 70 externally funded In-plant/General training programmes were conducted in the areas of quality, reliability, quality management systems, six sigma, customer satisfaction measurement and optimization techniques. A total of about 2000 participants were taught and trained in these programmes.

Six Sigma Training and Guidance for Improvement of Quality and Customer Satisfaction was given to the following organizations in INDIA:

MICO, Bangalore; ELGI Equipments, Coimbatore; L.G Balakrishnan & Bros. Coimbatore; Reliance Industries Ltd., (Patalganga), L&T Komatsu, Bangalore; KEC, Bangalore; L&T, Mysore; Macmillan, Bangalore; HP Global e-Business Operations Pvt. Ltd., Bangalore; Grindwell Norton, Bangalore; AT & S India Ltd., Nanjangud; Grasim Industries, Harihar; ABC Business Solutions Pvt. Ltd., New Delhi.

Quality Management Systems guidance for implementation and improvement was given to the following industries:

HMT International Ltd., Bangalore, IFB Automotive Seating Ltd., Bangalore, Rao Insulating Company, Bangalore, Ottobilz (India) Pvt. Ltd., Doddaballapur.

Guidance and Training for Six Sigma implementation in the organizations abroad were provide to Iran Khodro Company, Iran; IndoRama Chemicals, Thailand,

Training on Statistical Applications in Quality management Systems implementation was given to KEMA Netherlands personnel by A. K. Chaudhuri in October 2003.

Awareness programme at Cochin during 2 ~ 3 January 2004, was conducted by SQC & OR unit, Bangalore. The seminar was organized at Nirmala College, Kerala. P K Perumallu and E V Gijo were the faculty for the programme. 70 faculty members from various colleges in Kerala participated. The topics covered were Implementation of ISO 9001:2000 in education and Implementation of Six Sigma in Education.

SQC & OR Unit, Baroda

Teaching and Training:

P. Mandal offered the course "Research and Quantitative Methods" during June03-November 03 in the M.B.A programme organized by Baroda Productivity Council, Baroda. Correspondence programme in Statistical Process Control was continued during the year 2003-2004.

Research Activities

Quality of Data for SPC

In this work, an attempt has been made to develop a framework for addressing data quality problems that were faced while implementing Statistical Process Control (SPC). Most of the large business houses today maintain large databases for controlling and improving their business processes. Consequently, data quality has emerged as a very important field of research. Most of the published research work in the area is either generic in nature or deals with problems in survey data. In addition to addressing data quality problems, a new set of data quality classes was proposed and various data quality problems related to SPC were classified accordingly.

P. Mandal

Externally Funded Projects (Non-Income Sharing):

Sl.No.	Industry Served	Title of Project/Purpose of visit
1	ONGC, Baroda and Mehsana	Implementation of ISO 9001:2000
2	Devarson Industries Ltd., Ahmedabad	Guidance on Designed Experimentation
3	Tata Chemicals Limited, Mithapur	Implementation of SPC

4	Munjal Auto Ltd., Waghodia	Guidance for TOPS 8D projects
5	Bombardier Transportation Ltd., Halol	Development of economic sampling plans

P. Mandal was the visiting faculty in all the industries served.

Externally Funded In-plant/In-house Training Programmes:

Sl. No.	Title of the programme	Dates	Organization
1	Internal Auditing for ISO 9001:2000	Sep. 02 - Apr. 03	CAN-ORG-MARG, Baroda
2	Statistical Process Control	Sep. 03	Tata Chemicals Ltd., Mithpur
3	Birla Cellulosic Ltd., Kharach	Oct. 03	Problem Solving

SQC & OR Unit, Chennai

Research activities

Product Warranty Analysis:

Two-dimensional process was modeled by Gumbel's bivariate exponential distribution, and warranty cost was estimated for a real-life problem.

Research work on statistical modeling of two-dimensional warranty process was undertaken. For a multi-module product (with two-dimensional policy), warranty cost was derived through one-dimensional approach using Marshall-Olkin's multivariate exponential distribution.

Surajit Pal and G.S.R. Murthy

Theoretical research on modeling of two-dimensional process was undertaken. A general framework for statistical modeling of such processes was developed for system (product) level analysis.

D.K. Manna and Surajit Pal

Process Capability Indices:

A method was described to analyze non-normal process data by using generalized lambda distribution in order to evaluate generalized process capability indices.

Surajit Pal

Distributional properties of the estimator for C_p - C_{pk} were derived for the normal process The distribution was shown to be related to (singly) non-central F. A new relation between Owen's Q-function and Incomplete Beta function was also obtained in course of the work.

D. K. Manna

Co-operative Game Theory:

In the area of Co-operative Game Theory, contributions in the stability and largeness of core brought about some clarity and the set of lower boundary points of the set of acceptable pay-off vectors were understood to be of importance to decide the largeness of the core of a cooperative game. Work is now on to characterise these lower boundary points, the problem is combinatorial in nature. Attempts are also on the find a stable set solution for a general Assignment Game.

A. K. Biswas

Semi-Definite Linear Complimentarity Problem (SDLCP):

It is known that under SDLCP set up P and Q properties are equivalent for Lyapunov and Stein transformations. For the double sided multiplication Transformation M_A, the equivalence of P and Q properties could be shown when (i) A is in R^{2X2}, (ii) $A= A^t$, A is in R^{3X3}. Several interesting results were obtained which were used to prove the above. However the equivalence of P and Q properties still remains an open problem.

D. Sampangi Raman

Statistical Methods to Study Effectiveness of New Engine Oil.

Newly designed engine oil was evaluated against existing oil, based on several performance parameters under actual field condition. Values of performance parameters were observed at pre-determined mileage (sampling points) when the engine was run. Thus, the required statistical methods involved analyses of repeated measurements. Analysis of data indicated that the test oil was uniformly superior to that of reference oil. A user-friendly worksheet in MS-Excel was developed to carryout such analysis along with the relevant graphs routinely for meaningful interpretation.

Externally Funded In-plant/General Training Programmes

Sl.No.	Title of the Programme	Duration	Organization
1	Design of Experiments	2 days each	Ashok Leyland Ltd. & Rane (Madras) Ltd.
2	Statistical Methods	2 days	Chemplast Sanmar Limited
3	Six Sigma	½ day	BHEL
4	Basic Statistical Methods	3 days	Kemin Nutritional Tech (I) Pvt. Ltd.
5	Design FMEA	1 day	Simpson & Co. Ltd.
6	Part Time Program on SPC	1 month	General Training Program
7	Process Capability Analysis	2 days	General Training Program
8	Part Time Program on DOE	15 days	General Training Program
9	Design of Experiments	2 days	General Training Program
10	Statistical Tools for ISO 9000:2000 – Enroute to Six Sigma (jointly with QCI)	1 day	General Training Program

SQC & OR Unit, Coimbatore

Research and Other Scientific Activities

(i) A collaborative applied work was undertaken with Bharathiyar University for the Southern Railway, Coimbatore, to study the customers' murmuring due to dissatisfaction before the reservation counters at Coimbatore railway junction and to suggest remedial actions. The queuing pattern before the reservation counters could be adequately modeled and their parameters were estimated. Based of these estimates, recommendations were given on optimal number of counters required, and allocation of counter working time on each day for each period of time.

(ii) A collaborative work was carried out with the Bharathiyar university on optimum placement of various sizes of 'print layout' in order to minimize 'paper waste' in a printing industry.

(iii) Techno-economic breakthrough viability studies under government rehabilitation scheme for spinning mills was conducted. A new methodology was proposed and was accepted by SBI & IDBI for restructure strategy of NPAs.

(iv) Six sigma implementation at 'Office Process' in a spinning mill at Sambandam Mills, Salem, was taken up. The study is still continuing.

(v) Study of evaporation loss of petroleum products was undertaken in retail outlets of Hindustan Petroleum. Improved handling/calibration techniques, storage and logistics methods were proposed. Consequently, about 300 litres per month (2.5%) was projected as the expected savings in every retail outlet. Therefore for 1500 outlets of the organization, there would be significant savings through optimum inventory management in petrol alone.

(v) A project has been undertaken at six retail outlets of Hindustan Petroleum in Coimbatore, Pollachi and Sulur for introduction of ISO 9000 quality system.

A. Rajagopal of Coimbatore unit worked on all these projects, (i) - (vi), during 2003-2004.

In addition to the above projects, a number of other externally funded projects were also taken up by the Coimbatore unit during the year 2003 - 04. A Rajagopal and C. S. Pillai were associated with these projects. A brief list indicating the title of the projects and the funding organizations is given below.

Funding Organization	Title of the Project
Hindustan Petroleum	Quality Improvement, Quality System Implementation, and Attaining Consistent Density with Optimum Minimising Studies.
SRC Projects (P) Ltd.	National road project on prevention measures towards early completion and implementation of TPM.
Sangeeth Textiles (Annur)	Product Quality Improvement and Developmental Studies.
Durairaj Mills, Pasur	Variation Control in Process.
Shiva Textiles	Kaizen Studies.
Thangavelu Spinning Mills, Salem	Improving Quality of Process and Product.
Rajaratna Mills	Strategic Decision of Product Mix and Financial Viability.
TEXMO	Process Optimisation through Breakthrough Studies – Foundry Application in Pump Set Manufacturing.
Kalpakkam Atomic Power Plant	Geological Data Analysis for the Prediction of Founding Level at Atomic Power Plant at Kalpakkam
Rajapalayam Mills, Sri Vishnu Shanker Mills, Sudarsanam Spinning Mills	Implementing SQC Techniques in Routine Production and Waste Minimization.

Externally Funded In-plant Training Programme

Sl. No.	Title of the Programme	Duration	Organization
1	Statistical Process Control	10 - 11 April, 2003	K S B Pumps, Coimbatore

SQC & OR Unit, Delhi

Teaching and Training

Faculty support was provided for M. Stat. (Ist yr.) at ISI, Delhi. Faculty members acted as supervisors for projects of M.Tech. (QROR) students during the year 2003-2004.

Research Activities

Reliability: Consecutive K-out- of- n: *F* System, Linear Complementarity Problem(LCP), Semidefinite Linear Complementarity Problem(SDLCP), Noncooperative games, Stochastic Games.

Madhur Malik, (Supervisor: S. R. Mohan)

Projects:

Proficiency Testing Programme on Egg Powder Testing

In all 73 laboratories from 27 different countries participated in this programme. Statistical analysis was carried out by SQC & OR unit, Indian Statistical Institute, Delhi Centre to assess the performance of the participating laboratories on the various characteristics of egg powder.

Minimization of Heat Rate in Power Generation

Heat rate and auxiliary power consumption are the two important indices determining the economics of any power plant. Little work has earlier been done in use of statistical methodology in these areas. The project carried out in NTPC was a pioneering exercise and will go a long way in improving heat rate and auxiliary power consumption in power plants and achieved reduced cost power production.

Optimization Methodology and Algorithms for Printing Sheets

In this project an optimization model and algorithms for printing of sheets was developed in a large printing press based on demand pattern in finite horizon to minimize wastage of sheets and minimize the masters used for printing.

Development of Control Procedure for Thickness at Grinding

In Grinding, day to day variation of thickness was high. This was traced to the machine software on investigation. Setting right the intake procedure of the software helped to remove the day to day variation. To control the process a combined EWMA Chart was developed which efficiently detected even small shifts in mean as well as variability.

Implementation of Six Sigma Methodology in Non Manufacturing Area

Implementation of Six Sigma methodology in non-manufacturing area was done through training and project sessions. Specialized training materials were developed for participants from Marketing, H.R., Sales, Finance, Stores and Purchase. Project teams carried out several improvement studies.

Development of Suitable Control Procedure in Dicing Area

The variation in Kerf width in the Dicing process was observed to be very high. Subsequent to planned data collection, ANOVA for a random effect model with parameters chip geometry, wafer and error was used to estimate the inherent process variability. A trial implementation of $\bar{X}$ -Chart, based on this estimate performed satisfactorily and, was adopted for control of Kerf width.

Study of Variation in V/I Value at Oxidization Stage

Variation in V/I value, most important electrical parameter at oxidation stage, was very high. A designed experiment with temperature of the furnace and zones of the wafer was conducted. A suitable variance stabilizing transformation of the data was used as heteroscedasticity existed and ANOVA for a nested classification was carried out with the transformed data. Based on the analysis an action plan to tackle the problem was worked out and had been put to use.

Externally Funded In-plant and General Training Programmes:

Sl.No.	Title of the Programme	Organization	Duration
1	Statistics in Six sigma	Scope international (Standard Chartered Bank), Chennai	12-15 May 2003
2	Proficiency testing for laboratories	General Training Programme at Pune By Delhi Unit	10-12 July 2003
3	Sampling techniques and Inspection	Rites, Gurgaon	10-12 July 2003 04-06 Sept. 2003
4	Six Sigma Green Belt	General Training Programme at ISI, Delhi Centre	17-19 Sept. 2003
		R Systems International Ltd.	25-27 Feb. 2004
5	Statistical Process Control and Measurement System Analysis	Motherson Soumi Systems Limited	18-19 Dec. 2003
6	Structured Problem Solving		23-24 Dec. 2003
7	Statistical Tools for ISO 9000:2000	General training programme (In association with QCI) at Hotel Le Meridian, N Delhi	7 Feb. 2004

Special Assignment

A two-day survey on Quality status was carried out in M/S Texcorp Ltd. during 24-25 April 2003, to assess the company's present system of inspection and other control procedures, and to suggest remedial measures to rationalize the inspection system.

SQC & OR Unit, Hyderabad

Teaching and Training:

Teaching in Part-time Certificate Course in SQC continued for two new batches during February-September 2003 (30th batch) and October'03 – March'04 (31st batch). A total of 21 and 22 students were admitted in the respective batches. 14 students of the first batch took the final examination.

G.S.R. Murthy taught Advanced Inference to the students of M.Sc. Statistics, II year, of the University of Hyderabad during July-September 03.

P. Bhimasankaram taught : i) Applied multivariate analysis to M.Sc. final year students of University of Hyderabad during April-May 2003, ii) Probability in summer training programme for Math Olympiad students organized by University of Hyderabad during May – June 2003, iii) Applied Multivariate Analysis and Econometrics-I in the post-doctoral programme of Indian school of Business, Hyderabad during 23 June to 31 August 2003, iv) Linear Models and Regression to M.Sc. First year students of University of Hyderabad during January-March 2004, v) Statistics in Management to 1st year students of post graduate programme in Agribusiness management of MANAGE, Hyderabad.

All the faculty members acted as supervisors for project works of the students of the Part-time certificate course in SQC. A.L.N. Murthy guided project work of an MCA student on "Development of Irrigation Water Supply Scheduling Package". S. M. Subhani guided projects of 13 students pursuing M.Sc. / MCA courses. N.T.V. Ranga Rao guided project training for one M.Sc. (Computer Science) student on "Interpreting the SPC charts" – through development of appropriate software.

Research activities

Regression Analysis

Research in the area of Applied Regression Analysis with special emphasis on deletion diagnostics, collinearity and heteroscedasticity is in progress.

P. Bhimasankaram

Multivariate Statistical Process Control

Sensitivity Analysis in Multivariate Statistical Process Control.

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

Linear Complementarity Programming (LCP)

Research activity is being pursued on Linear Complementarity Programming (LCP) in association with the University of Hyderabad.

G.S.R. Murthy and T. Parthasarathy

Software Quality and Metrics

Scientific management system for irrigation and water supply is being developed.

A.L.N. Murthy and G.S.R. Murthy.

Six Sigma

Research in the area of Six Sigma / BFSS break through strategy (DMAIC / DMADV) for further refinement of the methodology is being pursued. A handbook for reference in Six Sigma Black Belt training is also being written.

G. Murali Rao

Design of Experiments

Applied research for optimisation of cigarette design with respect to different characteristics; to obtain Process Capability Indices for non-normal characteristics of cigarettes; and on using statistical methods for designing of filter elements for liquid and air had been carried out.

S. M. Subhani

Externally Funded (Consultancy) Projects:

Sl.No.	Funding Organization	Description of work
1	AVINEON India Technologies Ltd., Hyderabad	14 projects for Six sigma implementation are being pursued in the areas of quality, Productivity, cost and customer satisfaction. (Ongoing)
2	Tecumseh India Ltd. (Technology Development Centre (TDC))	Guiding 14 projects taken up by the TDC of Tecumseh India Ltd. on product design and development. (Ongoing)
3	CADSYS Technologies Ltd., Hyderabad	ISO 9000 : 2000 implementation. (Ongoing)
4	MIKROFLO Filters Ltd.	Introduction of quality system. The organization received ISO 9000:2000 certificate from LRQA.

Externally Funded In-plant/General Training Programmes

Sl. No.	Title of the programme	Dates	Programme conducted for & Venue	Number attended
1	Awareness programme on ISO 9000 : 2000	April-May'03	Cadsys Technologies Pvt. Ltd.	20
2	Internal Quality Audit	Sept. 22-23, 2003		12
3	Executive briefing on Six Sigma	June 14, 2003	Speck Systems Pvt. Ltd.	10
4	Statistical Techniques for Software quality	Aug 11-12, 2003	Wipro Technologies Ltd., Hyderabad	25
5	Awareness programme on Optimisation techniques.	Sept.17,2003	Infotech Enterprises Ltd.	10
6	Statistical techniques for software (towards achieving six Sigma performance)	Sept. 26-27, 2003	General training programme jointly organized with SPIN, Hyderabad.	20
7	Design of Experiments	Aug.18-22, 2003	TVS Srichakra Ltd., Madurai	25
8	Statistical methods applicable for optimizing the design of filter elements for various applications.	Aug. 6, 2003	Mikroflo Filters	7
9	Organisational transition from ISO 9001:1994 to ISO 9001:2000.	Aug.16, 2003		11
10	Process capability estimation for non-normal characteristics.	May 5, 2003	VST Industries Ltd.	6
11	Orthogonal Arrays for optimizing process parameters of FTL lamps for achieving star rating.	July 22, 2003	Wipro Lightings, Mysore	21
12	Statistical Process Control.	Aug 12-14,03	Centre for Electronics & Test Engg.	6