Seventy First Annual Report

April 2002 - March 2003

INDIAN STATISTICAL INSTITUTE

203 Barrackpore Trunk Road

Kolkata - 700 108

PRESIDENT OF THE INSTITUTE, CHAIRMAN AND OTHER MEMBERS OF THE COUNCIL AS ON MARCH 31, 2003

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

1. Chairman : Dr. N.R. Madhava Menon, Vice-Chancellor, The WB National University of Juridical Sciences, Kolkata
2. Director : Prof. K.B. Sinha, FNA.

Representatives of Government of India

3. Dr. A.C. Kulshreshtha, Additional 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 Divison, 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 Mata, 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. Mononranjan 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. Alake Dey, Head, Delhi Centre.
29. Prof. I.K. Ravichandra Rao, Head, Bangalore Centre.
30. Prof. Gour Mohan Saha, Dean of Studies.

Non-Member Secretary

Dr. S.K. Majumdar, In-Charge (Administration and Finance).

INDIAN STATISTICAL INSTITUTE

Annual Report
April 2002 – March 2003

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(http://www.isical.ac.in)

INDIAN STATISTICAL INSTITUTE
SEVENTY FIRST ANNUAL REPORT
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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. Sankhy$\bar{a}$, 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 visit 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 design, 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 research, 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 for the development of new statistical methods. The Institute has always remained on 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, project and administrative service activities of the Institute were regrouped into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 1996.

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

The year 2002-2003 in the Indian Statistical Institute, like most other years, saw its faculty gather their honours and awards – Professors S. Thangavelu and B.V. Rajarama Bhat of the Bangalore Centre received the Shanti Swarup Bhatnagar award and Swarnajayanti Fellowship respectively. Also Professor P.P. Majumder of the Anthropology & Human Genetics Unit was awarded the G.D Birla award while Professor B. Chanda of Electronics & Communication Sciences Unit received the Hari Om Ashram Prerit Vikram Sarabhai Research award. It is worth a special mention that our young colleague Dr. Debashish Goswami in the Theoretical Statistics & Mathematics Unit in Kolkata has been selected as an Associate of the Indian Academy of Sciences, Bangalore and a Junior Associate of the I.C.T.P., Trieste, Italy. All of them deserve our heartiest congratulations.

The central matter that occupied many minds during the year is the report of the Third ISI Review Committee. The Council of the Institute has been engaged in deliberations on various recommendations of the Third ISI Review Committee in order to renew/reorient ISI in the new era so that it emerges a stronger, better Institution. The Council has welcomed certain recommendations of the Review Committee and has also disagreed to accept some other recommendations, both with reasons and introspection. Some of the comments of the Review Committee, though apparently critical, may be turned around for the benefit of the Institute in the long run. We would try to blend changes with continuity and refocus our attention to research in statistical theory and methods and their quantitative applications in other sciences. As has been asserted again, the Indian Statistical Institute remains primarily a research Institution with some teaching to complement research. However, to make that assertion more meaningful as well as to deserve the title "Institute of National Importance", the research profiles of many of the Units/Divisions have to improve considerably. To achieve this, the Institute has to display an upward-moving vision in research and teaching, and accordingly some serious adjustments may have to be done. The Institute needs all our colleagues to come forward and join hands in this very important task.

Beginning this academic year, the new Master of Mathematics (M.Math.) course is being offered in the Bangalore Centre and we expect the same course to be introduced in Kolkata also from the next year. These, along with already existing Bachelor of Mathematics (B.Math.), Master of Science in Quantitative Economics (M.S.(QE)), Master of Technology in Computer Science (M.Tech.(CS)), Master of Technology in Quality, Reliability & Operations Research (M.Tech.(QR & OR)) courses, fulfil to a small degree the national goal of bringing the basic pre-Ph.D. education in the primary disciplines of our younger generations at par with that in Statistics. This is a major achievement and the Institute is indebted to all the involved faculty for making this possible. As a support to the new academic programmes, the Central Library too has improved in physical appearance and the range of services it offers has been modernized and expanded substantially.

At the Headquarters in the Kolkata Campus, the boundary wall on the entire B.T. Road stretch and the civil works of the phase I of the construction programme are nearly over and we would expect them to be handed over for occupation in the course of the next six months. The Institute is thankful to the architects, the construction companies, the Engineering Unit and the Works Advisory Committee of the Institute for such a remarkably fast completion of the project against many odds. The next phase envisages the construction of the rest of the boundary wall, a tunnel connecting the two parts of the campus, a new electrical sub-station, the Academic building II and possibly an indoor sports complex. In another five years or so, when all these projects are expected to be completed and when they begin to be used, the campus in Kolkata will indeed have a modern look and can hope to keep pace with the aspirations of the new century. Personally, I am happy to have been a part of this process. The Institute is also planning for the renovation of the Amrapali building which houses the P. C. Mahalanobis museum and archives.

K.B. Sinha

March 31, 2003

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 2002-2003 is given below.

During the academic session 2002-2003 a total of 9708 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), 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 (Bangalore), Research Fellowships in Statistics, Mathematics, Economics, Computer and Communication Sciences, Physics and Applied Mathematics, Linguistics, Sociology, Demography, Library and Information Science, Psychology, Geology and Biochemistry. Admission tests were conducted at 24 different centres all over the country. A total of 7028 candidates finally appeared for admission tests and a total of 416 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests, interview and the academic record, 191 candidates were offered admission to various courses during the academic session under review.

The annual examinations for all the regular courses of 2001-2002 were held in May-June 2002. The 2002-2003 academic session commenced in July-August 2002.

One hundred twenty 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, 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 Kalpataru Institute of Technology received a two week/six week/two month/six month Project training in different Computer Science Units of the Institute, viz., Electronics and Communication Sciences Unit, Computer Vision and Pattern Recognition Unit, Computer and Statistical Services Centre, Machine Intelligence Unit, Advanced Computing and Microelectronics Unit and Applied Statistics Unit.

The number of candidates admitted to the different degrees, diplomas and training courses in 2002-2003 and the number of students who passed in the annual examinations in 2002 are given below.

INDIAN STATISTICAL INSTITUTE

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES.

Sl. No.	Course	Number of Students	
		Passed in the Annual Exam. in 2002	Enrolled in 2002-03
Degree			
01.	Bachelor of Statistics with Hons. {B.Stat.(Hons.)}		
	1st year	22	25
	2nd year	18	22
	3rd year	18	18
02.	Bachelor of Mathematics with Hons. {B.Math.(Hons.)}		
	1st year	13	15
	2nd year	7	8
	3rd year	-	7
03.	Master of Statistics (M.Stat.) (S-Stream)		
	1st year	26	35
	2nd year	31	26
04.	Master of Science in Quantitative Economics{M.S.(QE)}		
	1st year	23	20
	2nd year	23	23
05.	M.Tech. in Computer Science		
	1st year	22	16
	2nd year	24	21
06.	M.Tech. in Quality, Reliability & Operations research		
	1st year	13	14
	2nd year	9	13
Certificate/Diploma			
07.	Diploma in Computer Programming and Applications (DCPA)	4	-
08.	Junior Diploma in Statistics (JDS)	1	-
	Senior Diploma in Statistics (SDS)	2	-
09.	Associateship in Documentation and Information Science (Bangalore)		
	1st year	8	6
	2nd year	5	8
10.	Junior & Senior Research fellows and Research Associates in different disciplines	11	16
	Grand Total	**280**	**293**

Ph.D. Degrees Awarded

(A) Ph.D. Degrees awarded by the Institute :

Sl. No.	Name of the fellow	Title of the Thesis	Name of the Supervisor(s)
1.	M.Usha, M.Sc. (Mathematics), University of Hyderabad	Symmetric Travelling Salesman Problem : Some New Insights	T.S. Arthanari

2.	Bappaditya Mukhopadhyay M.A. (Economics) University of Delhi	Essays in Financial Intermediation	Shubhashis Gangopadhyay
3.	Atanu Sengupta M.Sc. (Economics), University of Burdwan	Farm Efficiency in Indian Agrituiture : An Analytical Study Based on West Bengal	Manabendu Chattopadhyay
4.	Mohammad Khanjari Sadegh M.Sc. (Statistics) Ferdowsi University, Iran	Some Contributions to Reliability Analysis of a Consecutive-k-out-of-n:F System	Arvind Seth
5.	Soumen Maity M.Sc. (Statistics) University of Calcutta	Some Combinatorial Designs in VLSI Architectures and Statistics	Bimal Kumar Roy
6.	Sounaka Mishra M.Sc. (Mathematics) University of Sambalpur	On the Approximability of Linear Ordering and Related NP-optimization Problems	K. Sikdar
7.	Brati Sankar Chakraborty M.Sc. (Economics), University of Calcutta	Essays on Trade in Goods and Factor Movements Under Increasing Returns to Scale	Abhirup Sarkar
8.	Partha Sarathi Chakraborty M.Stat. (ISI)	Spectral Triples and Metric Aspects of Geometry on Some Noncommutative Spaces	K.B. Sinha
9.	Gurbachan Singh M.A. (Economics) University of Delhi	Some Aspects of Banks and Financial Markets in Emerging Economies	Subhashis Gangopadhyay
-10.	K.V.S. Vinay M.A. (Economics), University of Delhi	Essays in Indian Corporate Finance	Subhashis Gangopadhyay

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

Sl. No.	Name of the fellow	Title of the Thesis	University/ Institute	Name of the Supervisors
1.	Monika Roy	Human Uterine Cervical Cancer Prevention : High Risk Human Papillomavirus and other Factors	Jadavpur University, Kolkata	C. Duttagupta and S. Sengupta

International Statistical Education Centre (ISEC), Kolkata

The International Statistical Education 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. The Centre 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.

A total of 24 candidates have been offered admission to the 56th term of the Regular Course of this Centre. Of the 24 candidates, 21 joined the course. 16 trainees were supported by fellowship awarded by Government of India under the Technical Co-operation Scheme of the Colombo Plan (TCS of Colombo Plan), Special Commonwealth African Assistance Plan (SCAAP), Indian Technical and Economic Co-operation (ITEC), 4 trainees were supported by Asian Development Bank and 1 trainee was supported by the Commonwealth Fund for Technical Cooperation.

All the trainees in the Regular Course have successfully completed the course and have been recommended for the award of Statistical Training Diploma.

The Regular Course of the fifty sixth term started on 1 June 2002. 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 23, 2002 to November 01, 2002. This was followed by eight-week training at Kolkata in general statistical methods for optional subjects during Nov. 05, 2002 to January 03, 2003. In this phase the trainees pursued some of the courses (at least four) studied by them during the first four months more vigorously. Finally, from middle of January to March 2003 the trainees specialized in particular fields of applied statistics like demography, data processing, large-scale sample surveys and Economic Planning. All these Specialization Courses except 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.

Professional Examinations in Statistics

The Indian Statistical Institute holds Professional Examinations in Statistics in the theory and practice of analysis of statistical data, for 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 recognises 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 for employment purposes.

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, Kolkata, Chennai, Delhi, Hyderabad, and Mumbai).

The total number of candidates registered, appeared and passed for February 2002 term and December 2002 term are given below :

Examination	Registered		Appeared		Passed
	Feb 2002	Dec. 2002	Feb 2002	Dec 2002	Feb. 2002
1. Junior Diploma in Statistics (JDS)	44	33	23	19	09
2. Senior Diploma in Statistics (SDS)	11	08	08	04	04

The cumulative total number of candidates who have qualified for the award of the Diplomas in the Professional Examinations in Statistics is 291.

2. CONVOCATION

Thirty Seventh Convocation

Indian Statistical Institute held its thirty seventh Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research), M.Stat., M.S. (QE) and B.Stat. (Hons.) degrees and diplomas, Associateship, etc. on March 21, 2003.

Professor M.G.K. Menon, FRS, President of the Institute presided over the convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor K.B. Sinha, FNA, Director of the Institute presented the annual review of teaching and training activities of the Institute. Dr. R. Chidambaram, Principal Scientific Adviser to the Govt. of India and DAE-Homi Bhaba Professor, Bhaba Atomic Research Centre delivered the convocation address.

The numbers of students who obtained Degrees, Diplomas, Associateships and Awards in the convocation are given below :

Degree/Diploma	Number of Candidates
Doctor of Philosophy	10
Master of Technology (M.Tech.) in Computer Science	24
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	9
Master of Statistics (M.Stat.)	31
Master of Science (M.S.) in Quantitative Economics	23
Bachelor of Statistics (Honours) [B.Stat.(Hons.)]	18
Associateship in Documentation and Information Science	5
Diploma in Computer Programming and Applications	4
Professional Examinations in Statistics :	
Junior Diploma in Statistics	1
Senior Diploma in Statistics	2
Total :	127

Awards

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

Parthanil Roy

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

B.Stat. (Hons.) : Kshitij Deepak Khare

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M.Stat.	:	Sourav Chatterjee
M.S. (QE)	:	Mohitosh Kejriwal
M.Tech. (QROR)	:	Sandeep Talwar

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

Yellajosyula Sailaja

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 campuswide computer network in the Institute's headquarters at Kolkata and researchers, students, scholars etc. can now 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. This year the faculty members also took part in the teaching of UGC refresher course in Statistics, the six-month course of the International Statistical Education Centre and a course for ISS (Indian Statistical Service) Probationary Officers at Kolkata and the NBHM (National Board for Higher Mathematics) Nurture Programme at Bangalore. Members also 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.

INDIAN STATISTICAL INSTITUTE

Stat-Math Unit, Kolkata

The Unit is actively engaged in research in many areas of Statistics, Probability, Mathematics and Theoretical Computer Science. A brief account of the active areas of research of the unit, major work done, projects undertaken, publications, and the conferences organized during this year is given below.

Research Activities

The notion of almost constrained subspaces of Banach spaces and its relations with constrained, *i.e.*, 1-complemented, subspaces were studied. Existence of weighted Chebyshev centres for a general family of subsets of Banach spaces and its relations with intersection properties of balls were also explored, extending and improving upon some earlier results. These were also related with a modified notion of minimal points. An abstract geometric notion of a unitary in a Banach space, defined as those unit vectors whose state space spans the dual, was introduced and studied. The behavior of unitaries, strongly extreme points and weak*-unitaries were studied in the settings of C*-algebras, von Neumann algebras, L^1-preduals and the space of vector-valued continuous functions on a compact set. Studying the relation between the Mazur Intersection Property (MIP) and farthest points, it was shown in particular, that in a strictly convex space, every (weakly) compact convex set is the closed convex hull of its farthest points if and only if every such set is the intersection of closed balls containing it; and if X has the Radon-Nikodym Property (RNP), then similar result holds for w*-compact convex sets in X^*. A notion of strongly farthest points was also studied and strictly convex and locally uniformly convex spaces were characterized. The farthest distance map of a closed bounded set K and its subdifferential were also studied. A notion of subspaces called nicely proximinal subspaces was introduced and characterized. Spaces having RNP were characterized using nicely proximinal subspaces. Stability and transitivity results were also proved in some particular cases.

Criteria for finite generation of Noetherian subalgebras of polynomial algebras are being investigated. A salient feature of the results obtained so far is the discovery that, over regular rings, conditions on merely the codimension one fibres are sufficient for finite generation. Various examples have been constructed to illustrate the conditions.

Example of a family of non-MSF wavelets for the Hardy space $H^2(R)$ was constructed. An equivalence relation was introduced on the set of all single wavelets in higher dimensions relative to a matrix dilation, and the associated equivalence classes have been shown to be non-empty.

The classical Baum-Connes' conjecture states that the analytical assembly map from the equivariant K-homology of the universal space for proper action of a locally compact topological group G to the K-theory of $C^*_r(G)$ is an isomorphism. The construction of analytical assembly map was extended to the case of discrete quantum group and hence a quantum group version of Baun-Connes' conjecture was formulated. The study on "twisted equivariant cyclic cohomology" for the action of a compact quantum group has been completed and in particular, a canonical construction of "twisted equivariant chern character" using given spectral data has been done.

The problem of quantum stochastic dilation of quantum dynamical semigroups with unbounded generators has been taken up and various interesting classes of examples have been analysed in this context. In particular, a canonical construction of such dilation has been achieved for a class of quantum dynamical semigroups acting on UHF algebras, which are quite interesting physical models.

Furthermore, work is in progress to understand the structure of completely positive maps and semigroups on the hyperfinite type II_1 factors. Interesting and useful numerical invariants for the bimodule associated with a completely positive map on type II_1 factor have been obtained.

In Harmonic Analysis, results were obtained in connection with the Hardy's and Cowling-price uncertainty theorems on Semisimple Lie groups; it was shown that the critical case $ab = ¼$ of these theorems characterise functions closely related to the appropriate heat kernels. Progress was also made in the study of

Helgason Fourier transforms for which analogues of Hardy-Littlewood-Paley and Hausdorff- Young theorems were proved.

A model for river network has been developed using random walk technique along oriented trees.

Large dimensional random matrices have been studied with focus on random Toeplitz and anti-Toeplitz matrices. Some results on limiting spectral distributions of these matrices have been obtained.

A new property called Cesaro α integrability of a sequence of random variables has been discovered and using this, a number of new results on laws of large numbers (both weak and strong) have been obtained for independent as well as dependent random variables.

Asymptotic behaviour of the partial sums of records has been investigated. Some interesting correspondence between the limiting distributions of the partial sums and infinitely divisible distributions has been established.

Extension of Kakutani's dichotomy to the case of hidden Markov process where underlying process is a renewal process is being studied and related problems are being considered.

Properties of Random continued fractions, invariant measures for related Markov chains are being studied. Iterated function systems and the nature of stationary distributions is being investigated. An attempt is being made to understand the probability behind spin glass models.

Work is in progress on the study of optimal designs and related construction, identification of critical sets for Latin Squares and Orthogonal Arrays. These have a number of applications in cryptology and agriculture.

A family of probabilistic models for replication of DNA sequences has been developed and studied. These models have interesting implications from the point of view of evolutionary biology. Some Bayesian and non-Bayesian techniques have been developed for analyzing various types of grey level digital image data. Such techniques are useful in automatic identification of important features in images. Some nonparametric methods for classificatory analysis of high dimensional data have been developed.

A set of fMRI data collected from Bangur Institute of Neurology, Kolkata is being analyzed. The focus is on Bayesian methods. At the moment, estimation of HRF is being attempted at. The issue of motion correction has been addressed prior to this. Images of a traffic sequence has been investigated, with a view to identifying models of cars. At the moment, attempts are being made to extend the findings of the investigation to video images. The role of improper priors in sequential t-test has been investigated.

Problems related to multivariate finite populations have been addressed. A method of estimating mean vector of several principal variables has been developed using information on several supplementary variables as well as principal variables. The search for optimum probabilities of selection based on several size meeasures has been made and some new estimation procedures based on shrinkage technique have been defined. The results have useful application in socio-economic studies.

Various types of allocations of sample size to strata were investigated. Work also continued on the utilization of auxiliary information in sample surveys.

Work continued on Social Network Analysis. A measure of Reachability has been formulated.

Stat-Math Unit, Delhi

Research Activities

It was shown that the set of positive definite matrices with any of the unitarily invariant norms is a Finsler manifold of negative curvature.The classical Riemannian case is included in this. Some new positive

definite functions were discovered and used to obtain operator inequalities. Functions preserving the classes of nonnegative matrices, M-matrices and inverse M-matrices were studied. Characterization results were obtained for such functions, unifying some results in the literature.

Problems dealing with inference for stochastic processes modeled by stochastic partial differential equations and processes governed by stochastic differential equations driven by fractional Brownian motion were studied. Probabilistic inequalities and inference problems for associated sequences and characterization of probability distributions through binary operations were also studied.

Results on optimal fractional factorial plans for asymmetric factorials were obtained. Some results on optimal main effect plans with non-orthogonal blocks were obtained. Optimal block designs for biological assays and optimal cross over designs were identified.

Relationships between strong monotonicity property, P-2 property and GUS property in semidefinite linear complementarity problems were studied. It was shown that strong monotonicity implies P-2 property but the converse is not true in general.

Studies on geometry of quantum groups were continued. A breakthrough of sorts was achieved when an equivariant spectral triple for the $SU_q(2)$ group was found having nontrivial pairing with the K-theory. This triple was later used by Alain Connes to prove a local index formula for $SU_q(2)$. The method employed is largely combinatorial, exploits the compact resolvent condition of the Dirac operator, and helps not only to find an equivariant triple, it actually enables us to characterize all such triples. This is the first instance that this functional analytic condition has been captured in a combinatorial set up and analysed.

Stat-MathUnit, Bangalore

Research Activities

Using the Skorokhod problem, multidimensional reflected symmetric stable Levy processes were defined; an expression for transition probability density function of such processes was also obtained.

Results have been obtained in the area of Stochastic Differential Equations. Solutions of an equation for Brownian motion in the space of tempered distributions, which correspond to Brownian motion with an initial condition which is a tempered distribution were obtained. Also characterised were the finite dimensional solutions of an infinite dimensional equation. Another area of research where results have been obtained was the explicit form of the integrand in the Martingale Representation Theorem, using a (new) class of stochastic sobolev spaces. Also explicit probabilistic representations of the solutions of the Heat equation, when the initial condition is a tempered distribution, were obtained. In a different direction, the Markov properties of a process of time change by last entrance times is being investigated.

Asymptotic inference in fractionally cointegrated time series models, both linear and nonlinear, with possibly heavy tailed errors was studied. Solutions to the related research problems lead to several interesting and important problems in probability theory, the solutions of which are also of current interest. In particular, the weak convergence of nonlinear functionals of sums of fractionally integrated processes to local times of fractional Brownian motion and stable motions.

For the first time the existence was shown of dilations of completely positive semigroups to $*$-endomorphism semigroups which are not minimal but still 'atomic' in the sense that they have no 'smaller' dilations. It was also shown that such a phenomenon cannot occur for unital semigroups or for regular dilations. Work is being done on dilations of commuting tuples of operators. A notion was introduced called 'maximal' commuting 'piece' for tuples of Hilbert space operators. Given a commuting tuple of operators forming a row contraction there are two commonly used dilations in multivariable operator theory. Firstly there is the minimal isometric dilation consisting of isometries with orthogonal ranges, which is a noncommuting tuple. There is also a commuting dilation related with a standard commuting tuple on Boson Fock space. It was shown that this

commuting dilation is the maximal commuting piece of the minimal isometric dilation. This result was used to classify all representations of Cuntz algebra O_n coming from dilations of commuting tuples.

Considerable research was done in the area of Geometry of Banach spaces. The notion of a unitary in a Banach space was introduced and properties of Banach spaces that are rich in unitaries were investigated. Weak-to-norm upper-semi-continuity of the preduality map was studied. Conditions were given that ensure such points independent of the predual.

Complete analogues have been established for the Euclidean motion group and $SL(2, \mathbf{R})$. For NA groups analogues of Paley-Wiener and Hardy theorems have been proved. There are also versions of Beurling's theorem for certain Lie groups. This work on Hardy's theorem has culminated in a monograph titled "An introduction to the uncertainty principle : Hardy's theorem on Lie groups" to be published by Birkhauser soon.

Work is going on to prove existence of solution for the critical exponent problem $-\Delta u = \lambda u + h(x)\, u^{n+2/n-2}$ in R^n for $\lambda \geq 0$ and $n \geq 4$ assuming that the function h changes sign. Existence of the solution for $\lambda < 0$ and some Liouville type results for Pucci operator are being studied. New characterisation of a sphere in terms of simple condition on the boundary of a domain in Euclidean space was obtained.

Considering T-semi-selfdecomposability, operator selfdecomposability and subclasses $L_m(b, (T_t))$ and $\sim L_m(b, (T_t))$ of measures on complete separable metric vector spaces, basic properties were proved. In particular, it was shown that a probability measure μ is T-semi-selfdecomposable if and only if μ is (stronlgy) T-decomposable with an infinitely divisible cofactor and μ is operator selfdecomposable if and only if $\mu \in L_0(b, (T_t))$ for all $0 < b < 1$. Also considered was a class of probability measures with a decomposition property that are called autophage measures. It was shown that such autophage measures on finite-dimensional real or p-adic vector spaces are infinitely divisible without idempotent factors and are absolutely continuous with bounded continuous density. As an application it was proved that semistable measures on such vector spaces are absolutely continuous.

The structure of the code generated by lines of a regular generalized quadrangle of even order as the module for the orthogonal groups contained in the corresponding symplectic group was determined. The structure of the Sylow 2-subgroup of the Ree group as a module for the Levi factor of the normalizer of the centre of the Sylow 2-group was also determined. An expository notes (about 70 printed pages) on the concept of "Building" was distributed to the participants of the Instructional workshop and conference on Geometric Group theory at IIT, Guwahati held during Dec. 2-22, 2002.

The equation $x(x+1).....(x+m-1) + r = y^n$ (for m bigger than 2 and n at least 2) was investigated for solutions $r, y \in Q$ and $x \in Z$. Using results of Baker, Schinzel and Tijdemann, finiteness results - effective in m,n,x,y - were proved and all exceptions were found. It was proved that for any irreducible polynomial $g(y)$, and any $m > 2$, the equation $x(x+1).....(x+m-1) = g(y)$ has only finitely many solutions with bounded denomintors unless $m = 4$ and $g(y) = 9/16 + (a+by)^2$ when it has infinitely many. Some results were proved also for general (i.e. reducible) $g(y)$. Some commutativity theorems for associative rings satisfying identities were proved. Using a combination of combinatorial methods and the Chevalley-Warning theorem, some conjectures on zero-sum sequences in the product of the group Z_n with itself were studied. A conjecture of W Gao was proved for the prime 7. Cubic recurrences such that the associated polynomial has all roots real were studied. It was proved that such a recurrence can vanish at the most thrice. An example is the sequence $u_n = \sum_i (-1)^{[n-2i}\, C_i\, t^i$ where t is any positive real number less than 4/27. The recurrence here is $u_{n+3} = u_{n+2} - t\, u_n$. A graduate level monograph on 'the congruence subgroup problem' was completed.

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 Division 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.

Research Activities

Sample Surveys

In the context of randomized responses techniques, further theories of Randomized Response methods (both optional and compulsory) were developed especially for qualitative characteristics.

A method for putting desirable constraints on the size of the adaptive sample was proposed to overcome the inherent drawback of adaptive sampling where the size of the final adaptive sample may far exceed that of the initial one. An application of this method with Economic Census data was carried out.

In the context of stratified two-stage sampling assuming strata-wise non-response at every stage of sampling to occur at random, formulae for corrections in estimators for totals or means and their variances or mean square errors were derived with simulation-based studies of loss in efficiency due to non-response illustrating various unequal probability sampling schemes at the first and second stages. It was shown using bootstrapping techniques that the performance of the proposed estimators are substantially improved.

Design of Experiments, Combinatorial Methods and Their Applications

Cross-over designs were studied under a combined intra-inter model and optimality results were obtained from which many existing results follow as particular cases.. The concept of joint optimality was studied for cross-over designs and several optimality results were obtained. An optimality functional of practical interest was proposed and a class of designs was shown to be optimal for this functional in a general class. Universally optimal main effect plans for blocks of size 2 were obtained. Construction and optimality of nested row-column designs of small sizes were studied.

Biostatistics

Multi-treatment adaptive designs were studied for general multivariate responses. Some elimination rules were also studied in this context. Some adaptive designs were studied for general linear models with missing data. Some skewed biased coin designs for adaptive allocation in a phase III clinical trial with k treatments (involving covariates) were studied. Some Bayesian skewed biased coin designs were studied in this context. Some adaptive cross-over designs for phase III clinical trials were studied theoretically.

Some new probability models were introduced for bivariate binomial distribution and a detailed study of bivariate binomial and Poisson distribution was done.

A Markov chain Monte Carlo method was developed to explore heterogeneity between individuals while analyzing complex cancer data. A Poisson process approach was developed for investigating the effect of air pollution on multiple hospital admissions with respiratory diseases. The issue of bias-variance trade-off was addressed to come up with a suitable stratification model via likelihood based cross validation technique. An application of this method was considered with data from Seattle, USA. The method has application in analysis

of recurrent event data. The equivalence between cohort analysis and time series analysis of mortality or hospital admission data with air pollution indices was established under a general set-up.

Statistical methods for mapping quantitative trait loci were developed with special emphasis on non-parametric approaches like Kernel-smoothing. The non-parametric methods were used to analyze Beta 2 EEG data collected under the ongoing collaborative study on the Genetics of Alcoholism project funded by NIAAA. Extensions of existing sib-pair methods to incorporate larger sibships were also developed.

Reliability, Life Testing and Survival Analysis

A probabilistic model was developed for the analysis of risk incurred by a supplier who is liable for interruption of supply to a long-term client. The model provides a framework for assessing the impact of interrupting factors.

The problem of record linkage error while trying to link the exposure database with mortality database in an epidemiological study was partially investigated.

Cryptology and Computer Science

Some methods for cryptanalyzing stream ciphers when the combining function is correlation immune, or/and have memory, were developed. Characterization and construction of multi-output Boolean functions suitable for designing symmetric ciphers was done.

Efficient algorithms for arithmetic on the Jacobian of hyper-elliptic curves were developed and new scalar multiplication algorithms were designed. A new key agreement protocol based on bilinear maps obtained from Weil & Tate pairing has been developed. Digital watermarking schemes and visual cryptographic schemes for satellite images were partially developed.

Fractal Geometry is a new language in the field of computer graphics. A particular type of fractals was developed by using both cellular automata and graphics algorithms. Their dimensions were measured with probable explanations. The effort to ascertain which particular type of fractals will surely enhance the musical environment (i.e., to characterize fractal sounds) is under way. Also research on extraction of linearity of arbitrary non-linear mapping is going on. Some interesting results were noted. In particular, it was observed that some of the nonlinear mappings can be characterized only with the help of a few original Jacobian matrices which are effectively seen as hybrid rule matrices.

Inference

The efficiency of different selection procedures was studied in the context of normal selection. A graphical investigation of the robustness of the minimum disparity estimators was made. Tests of hypothesis in multiple samples based on penalized disparities were derived.

New goodness of fit tests were developed for the standard multinomial set up which has good power against all kinds of alternatives. An extension of this in the order restricted case appears to work particularly well.

Inference for change point models, both retrospective and prospective, was studied for a variety of linear and circular distributions. Multivariate extensions was also derived.

A high-dimensional model selection criterion was proposed and successfully applied to animal survival data.

Linear Models and Multivariate Analysis

The multivariate linear model with possibly singular dispersion matrix was studied, and standard results for the nonsingular case were extended to this model.

Linear discriminant functions based on censored training samples were studied for classification into one of two correlated populations. The effect of censoring on the probability of classification was investigated.

Models for possibly asymmetric distributions on the circle, torus and cylinder have been derived and exact and asymptotic inference for such models were also obtained.

Other areas

Some results related to permanental inequalities were proved.

Several new results related to the correlation inequality for convex sets under Gaussion distribution as well as results related to unlinkability of uncorrelated functions were developed.

Two Different methods of generating random 0-1 matrices were compared and used to conclude that co-existence of birds species in natural environment may not be random.

Projects Undertaken

A. Internally Funded Projects

Analysis of SODAR Data

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

Social Mobility Index with Application in SC Populations in Districts in W.B.

The project started with a data set on social changes in SC populations over generations collected in a few districts of West Bengal. This data was analysed with an objective to determine if there had been any improvement (mobility, in general) in those SC populations. Some suitable mobility indices were developed for this purpose. A statistical method was also developed to test if there has been any change with respect to a number of social parameters.

Risk Analysis of a long-Term Agreement

A probabilistic model was developed for the purpose of assessing the risk incurred by a supplier of raw material to a producer, who must receive an uninterrupted supply. A method of assessing the effect of various disruptive factors was also devised.

A study on Post Graduates in West Bengal

The objective of the study was to assess the employment situation among the postgraduates from three streams - Arts, Science and Commerce - to study the various characteristics of the students and to study the efficacy of some emerging methodologies in the field of Sample Survey, namely the Adaptive sampling and model-assisted procedures.

The sampling design used in the survey was a two stage stratified sampling and Rao-Heartley-Cochran scheme of sampling was used to sample the first stage units (subjects within different strata). The adaptive sampling methods were used to estimate the parameters such as domain totals, ratios and the ratios of two ratios. Some interesting results have been obtained in this study and further work is going on.

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 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. Kernel smoothing of data collected at Kolkata yielded correlated errors giving scope of further analysis along this line.

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 was proposed and this was 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 were constructed.

Externally Funded Projects

Cryptanalysis of complex LFSR based systems

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

Visual cryptographic schemes

A software was 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, were developed and implemented.

Developing audit sampling tools for the Department of Finance, Government of West Bengal relating to Public Works Department (PWD), Public Health Engineering (PHE) and Irrigation and Waterworks (IW).

The phase II project was to cover the whole of West Bengal but the sampled districts were Kolkata, Bardhaman, Birbhum, Maldah and Jalpaiguri where most of the PWD, PHE and IW offices in the state are located. The book-entries for the period 1.4.2000-31.3.2001 were being audited on choosing the district-wise offices by Rao, Hartley and Cochran's (RHC, JRSS B, 1962) sampling scheme using "total monetary transaction amounts for the financial year 1999-2000 as the size-measures". Within the offices various books were selected by stratified random sampling method, the pages within books and also the lines within selected pages by the stratified random method and columns from the chosen lines at random. Estimates of totals and of ratios of totals along with estimated coefficients of variation are to be presented in numerous tables focussing on the lapses in entries, if any, by diverse categories as was done for the Project, phase I, related to the Health Sector, which was confined only to the districts of Kolkata, North 24 Parganas, Burdwan, Hugli and Darjeeling excluding the Hill council areas.

Estimation of Denomination wise Age of Currency Notes in Circulation for Reserve Bank of India

Life distribution of currency notes withdrawn from circulation was estimated. The results showed regional differences in median life as well as differences vis-a-vis various denominations. Recommendations for further studies were given to RBI and these were accepted.

Steganographic Schemes for Satellite Images for ISRO

The aim of the project is to develop new and secure digital water marking schemes for ISRO images. The work started during the year under review.

Development of an Indigenous Block Cipher Scheme for ISRO

The aim of the project is to "customise" the internationally accepted block cipher standard called AES to ensure same level of security while ensuring that it is different from AES. The work started during the year under review.

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

The faculty members of this unit have been engaged in research activities centred around efficient algorithms and architectures in the following areas : Wireless Computing, Distributed Computing, VLSI Design and Test, Computational Geometry and Computational Biology. During 2002-2003, they also taught seven courses in M.Tech. (CS) programme and advised Masters and doctoral students of ISI and other academic institutions for their dissertation research.

Research Activities

Wireless Networks and Mobile Computing

In wireless communication, radio spectrum is a very scarce resource that is to be managed efficiently. The Static Channel Assignment Problem was investigated for hexagonal cellular networks with non-uniform demands from different cells. The problem is, in general NP-complete. The notion of a critical block was introduced, which provides optimal assignment for all eight well-known benchmark instances, and is better than any of the existing techniques in terms of total bandwidth and computation time. Those results are being extended to resolve the dynamic channel assignment problem by the application *of minimum perturbation techniques*.

Since the physical location of a mobile user no longer determines its network address, the mobility poses a major challenge in the call delivery process. With the increase in the number of users in a network, it is very important to find an adequate trade-off between searching and informing to keep the total overhead associated with it optimal. Neural networks trained by the movement profile of individual users to predict the

terminal's current location to facilitate paging were designed. Simulation results show a considerable improvement in the paging cost.

Performance analysis of different location tracking schemes needs a model that reflects the mobility of the mobile terminals in a realistic way. A random walk based model with *inertia* was proposed for this purpose. The mobility model was used to analyze the cost of movement-based as well as distance-based location update strategies.

Checkpointing in Distributed Systems

Checkpointing in distributed message passing systems is difficult for the requirement of finding Consistent Global Checkpoints. Though algorithms exist for checkpointing with multiple concurrent initiations for general topology, the performance of the existing algorithms is poor for the simple ring network. Checkpointing and recovery schemes were 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.

Multi-Mesh Architectures

The Multi-Mesh network was originally introduced by this research group in ISI; it supports a better architecture than the usual 2D mesh or torus. The basic scheme of interconnecting the processors in a Multi-Mesh was generalized to connect any number of nodes, i.e., it becomes incrementally extensible. It has been very effectively used in WDM (wave division multiplexed) optical networks because of its interesting feature of lower call blocking probability. Simulation studies were done to support the theoretical claim. Extension to higher order Multi-Mesh architectures for use in WDM networks have also been performed. Studies are being carried out for use of optical links for interblock links, thus providing improved execution time for different applications.

Geometric Algorithms

The research in the area of Computational Geometry was mainly focused on different optimization problems, which arises in *facility location*. Several online query answering problems were studied, for example, geodesic nearest neighbors of a point among polygonal obstacles, k nearest neighbors of a line or line segment, to name a few.

A special case of the point set labeling problem has been studied, which is an important problem in Geographic Information System. Here the problem is to label the point sites of a map, where (i) size of the label of each point is known *a priori*, and (ii) the point can appear in either top-left or bottom-left corner of its label. For each point, the corner specification is also known *a priori*. The objective is to label maximum number of points. It was shown that the problem can be mapped to finding the maximum independent set of a chordal graph, and an $O(n\log n)$ time algorithm was developed. Further, if the corner specification is not given and the point can appear in one of the four corners of its label, then the above technique can be used to get a factor-2 approximation algorithm in $O(n\log n)$ time. The experimental results are better than the existing ones.

Further work is going on efficient characterization of visibility graphs, and good algorithms for realizing polygons for a given visibility graph. This is a long-standing open problem and has applications to morphing and model based object recognition problems.

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

Design of zero-aliasing space compactor for response compaction in a sequential circuit was 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:

earlier 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.

Partitioning of Routing Area

The concept of topological routing, instead of channel routing, is applicable to the chips of today with several metal layers. 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 also designed. Additional constraints of non-overlapping zones with high priority for convex shapes were incorporated in the design of the graph-based heuristic for this problem. At the core of the heuristic lies a clique-partitioning formulation.

Reconfigurable Co-Processor Design based on FPGAs

Field-Programmable Gate Arrays (FPGAs) are used extensively to synthesize complex logic circuits by programming. A new technique for synthesis of large synchronous sequential machine, which has less hardware overhead, shorter test application time and a very high fault-coverage was developed. The design can be easily mapped to an FPGA-based architecture. An algorithm has been developed to obtain a good quality initial placement which reduces the number of iterations for arriving at the optimal solution.

Floorplanning for Deep Submicron Integrated Circuits

Dual voltage chips are becoming increasingly common in deep submicron low power technology. The floorplanning problem in this context has been formulated as finding a min-cut in a network derived from the given netlist and preferred adjacencies among the modules. The set of modules is bi-partitioned, if possible in a balanced manner, such that the modules using same supply voltage are in one partition. This is performed recursively along with the consideration of the sizing information of the modules.

Balanced bi-partitioning being NP-complete, a maxflow-mincut based heuristic with geometric constraints, has been designed. The convex mixed optimization for balance and min-cut has also been solved. This method provides an advantage of incorporating look-ahead for the global routing phase of the floorplan. Implementation and experimentation with benchmarks have also been carried out.

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/Cm^2, and this figure may be extrapolated to about 200Watts/Cm^2 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 first-cut methodology for modeling gate delay faults from power supply droop noise has been developed based on which the test pattern generation problem will be solved. This work was done in collaboration with engineers of Intel Corp., USA.

Genetic Algorithm for Double Digest Problem in Genetics

Restriction enzyme mapping is a well-known technique in molecular biology and the Double Digest Problem (DDP) was formulated as a NP-complete combinatorial problem. Existing approaches are neither able to tackle large instances nor able to produce all distinct solutions. An elitist genetic algorithm was proposed to overcome both the short-comings and obtain efficiently all distinct solutions to an instance of DDP. The notion of a particular type of equivalence among the solutions is utilized. The method comprises of two phases - first to employ the GA to find a representative solution from each equivalence class, and then for each of these to generate all members in its equivalence class. Experimental results tallied for instances with known results.

On-Chip Implementation for Content-based Image retrieval

The content based image retrieval (CBIR) problem was addressed 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. were 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.

Computer Vision and Pattern Recognition Unit

The faculty members of the unit were involved in teaching 9 (nine) courses of the M.Tech. (CS), M.Tech. (QROR), MS(QE) and 56th Term ISEC Regular Course and in supervising M.Tech. (CS) and M. Stat. dissertations. The senior faculty members also supervised 3 (three) Ph.D. students.

Research Activities

Document Analysis

The Oriya OCR system was improved for the recognition of compound (cluster) characters. A system was developed for multi-oriented line detection and their skew estimation. A prototype for Urdu isolated character recognition was developed. A system was developed to identify word-wise Devnagari, English and Telugu scripts from a single document page. Other pieces of work on document analysis, namely, automatic skew correction, recognition and segmentation of mathematical expressions, document lay-out extraction, etc. have been improved for better accuracy.

The problem of spotting keywords in document images based on shape-matching is important when dealing with documents for which OCR does not work well. To evaluate various shape-matching approaches, a test collection is needed. A moderately sized test collection was created for this purpose. The collection consists of about 20,000 word images and over 100 query words. The ground truth for this collection has been generated, and a program for automatic evaluation has been written.

OCR of technical/scientific documents is difficult because of the presence of large number of mathematical expressions. A simple context-free grammar was been designed to analyze structures of printed mathematical expressions. A new performance metric has been proposed to evaluate expression recognition systems.

Functional Magnetic Resonance Imaging for study of the human brain

In order to correct the image scans of the slight head movements that occur in the course of data acquisition, an algorithm was developed for image registration. The algorithm was designed so as to be not led astray by the presence of activation. It has been found to work very well for the registration of 2-D images and has been extended to the registration of 3-D or volumetric images.

Analysis of the registered 2-D images was carried out using the wavelet transform which is a very popular tool used for the study of non-stationary data. The transform has been used to (i) Remove 'noise' from the data which is a source of error in such images, and (ii) Model the activation by tracking a few large transformed components. In addition, the use of statistical methods to identify the activated areas through the wavelet coefficients, is being explored. Preliminary results on data that have been actually locally obtained, have been found to be encouraging.

Handwritten Character Recognition

A database of 12000 hand-printed Bangla numerals was developed. A set of more than one lakh isolated handwritten Bangla characters was collected. Two different recognition techniques for isolated handwritten numerals, one based on a hybrid method consisting of neural network tools and conventional techniques and the other based on wavelet features were developed. The latter technique has been tested on a standard (MNIST) database for English numerals and the recognition performance is comparable to the state-of-art techniques. For Bangla numeral database, its accuracy rate is 97.16%. Its recognition speed on a desktop computer is more than 60 numerals per second. For recognition of handwritten Bangla words, a scheme for skew detection and correction and a scheme for segmentation of individual characters were developed. For online handwriting recognition an algorithm was developed and tested for numerals. Test results show an accuracy of about 99% in writer-independent mode. An interface has been designed to collect data from multiple writers to study several properties of online handwriting. A technique based on classifier-fusion approach has been formulated to recognize online handwritten mathematical symbols.

Natural Language Processing

From the Bangla text corpus several words with spelling variation were collected and studied to identify the types of variation to be used for designing automatic spell checker system and spelling dictionary. Moreover, the consonant conjuncts have been analysed to define their articulatory peculiarities for speech synthesis. The formation and functional variation of the diacritics and punctuation marks used in Bangla writing were also analysed for the purpose of language education. Analysis of pronominal words has been done for automatic morphological processing. Linguistic rules for text to speech conversion of Bangla words were proposed and tested. From the Bangla corpus, various examples of polysemous words have been collected and analysed for understanding the nature of polysemy in Bangla.

The study on computational stylistics is continuing. Automatic machine translation work between Bangla and Hindi languages in the domain of weather forecast and natural calamity announcements is continuing. In addition to the Bangla-Bangla dictionary which is now ready, another Bangla-English computerized dictionary of 65,000 words has now been entered. It is being checked for any mistakes in data entry. The spell-checker designed earlier is now made more powerful and tested on a large corpus. An exhaustive work on Bangla onomatopoeic words is complete and writing a book has started on Bangla Sound symbolism. Also, a study of Oriya onomatopoeic word has been completed. Some studies on readability analysis of Bangla text have been done. Studies on word reduplication and echo words are going on.

Speech Processing

In the speech synthesis software developed earlier intonation and prosody is being incorporated so that the synthesized speech becomes more lively. Also, a few newer text-to-speech conversion rules have been incorporated into the system. A lab for capturing Bangla Speech Corpus is going to be developed. Primary classification scheme of different types of speech has already been made.

Information Retrieval

A number of information processing problems that have obvious and immense practical utility have been explored. One of the widely used passage retrieval techniques was studied and applied to build a prototype passage retrieval system for Bangla. A language-independent, n-gram based method for language identification and text categorization has been implemented. The use of Bayesian classification and Support Vector Machines for categorizing short text documents containing ungrammatical text has also been studied. The major techniques for domain independent question answering from large collections of English documents have been surveyed. Preliminary work on named entity identification has started. An entropy based approach to automatic summarization of English documents has also been formulated, but this needs to be properly tested. The various softwares mentioned above can be combined together to form a comprehensive toolbox that will be useful for various information processing applications.

Signal Encryption

A new method of signal decomposition and reconstruction was developed which is quite fast. Its decomposed components have the capability of hiding/protecting the signatures of the original signal. An interesting property of the reconstruction algorithm is that any error in the decomposed components leads to error propagation during reconstruction. Consequently, the reconstructed signal differs significantly from the original one. Finally, a method for generation of a lock sequence from a key of an arbitrary length was been developed on the basis of which the decomposed signal is encrypted. If the key is known, the original signal can be obtained from the encrypted signal. On the other hand, any error in the key leads to a large error in the decrypted signal making it perceptually unintelligible. The key space is large and hence the tightness of the key is significant.

Technology Transfers

The Devnagari OCR technology developed in the Unit was transferred to ER&DCI, Noida. Assamese OCR Technology was transferred to IIT, Guwahati. The transfer of Oriya OCR technology to OCAC, Bhubaneshwar has been initiated. Also, speech synthesis technology is being transferred to WEBEL.

Electronics and Communication Sciences Unit

Research Activities

Mathematical Morphology and Its Application in Image Processing

A multi-scale morphological technique was developed for color image enhancement. The performance of the developed technique was compared with other existing techniques for the same. An algorithm for automatic selection of structuring element based on local spatial information was developed. The technique was applied to the problem of Bengali numeral recognition and was tested on a large set of real images.

Image Compression

Kohonen's self-organizing feature map and surface fitting were employed to design a vector quantizer for image compression. The performance of the proposed technique based on a generic code book has been evaluated against other well known methods. A tree-structured index grouping algorithm was also developed for lossless coding of the VQ index map.

Analysis of Remotely-sensed in Data for Resource Management

A deterministic clustering technique was developed based on a symmetry measure. The proposed method determines a set of plausible hyper-spherical clusters in the multi-dimensional feature space. These clusters are then merged and split using simple overlapping criteria. The technique is applied to unsupervised classification of landcover using multispectral satellite images. A system was developed for identifying and recognizing some important geographical features. This leads to automatic interpretation of conventional printed maps.

NN Based Image Processing

A neural network based thinning algorithm was developed, using different activation functions at different layers. It removes the boundary pixels from four directions in such a manner that the general configuration of the input pattern remains unaltered and the connectivity is preserved.

Neural Networks for Computational Geometry

A two layer neural network was proposed for computation of an approximate convex-hull of a set of points or a set of circles of different sizes. The algorithm is based on a very elegant concept -- shrinking of a

rubber band surrounding the set of planar objects. Logically, a set of neurons is placed on a circle (rubber band) surrounding the objects. The given set of points/objects exerts a force of attraction on every neuron, which determines how its current position will be updated. As the network evolves, the neurons approximate the convex-hull more and more accurately. The scheme is quite general in nature and can be applied to find the convex-hull of a set of circles or ellipses or a mixture of the two.

Evolutionary Computation for Classifier Design

A new approach for designing classifiers using genetic programming was proposed. Unlike other approaches, the proposed method takes an integrated view of all classes while evolving the classifier. In this regard, new cross-over and mutation operations are proposed which reduce the destructive nature of conventional genetic operators. A novel concept of unfitness of a tree was introduced and a new method of integrating chromosomes of the terminal population was developed resulting in much improved classifiers.

Fuzzy Logic and Theory of Evidence for Satellite Image Analysis

Novel methodologies were developed for extraction of fuzzy rules for classification of land-covers from multi-spectral satellite images. The performance of the system was further enhanced exploiting the contextual information through fuzzy k-nearest neighbor approach and Dempster-Shafer theory of evidence. In this regard several information fusion methods were proposed. The systems are found to give excellent performance.

Bioinformatics

A set of new features were proposed for prediction of protein folding. The set of features were computed keeping in mind the energy modeling that is often used in threading and *ab-initio* fold prediction. The effectiveness of the new features is demonstrated through neural learning machines. Online feature analysis mechanism was also used to reduce the dimensionality of features used that are often used for protein fold prediction. In this regard a novel hierarchical neural learning machine was used.

Developing Efficient Algorithms For Content Based Image Retrieval

The focus was to improve the retrieval quality through better image segmentation algorithm. A model CBIR application software which is now available though Internet was implemented. Two new algorithms to protect image contents were developed. While the first one manipulates pixel values in spatial domain, the second algorithm embeds the watermark in the wavelet domain.

Tracking

The problem deals in identification and tracking of leukocytes within blood vessels (of mouse cremaster muscle) for drug testing and monitoring. This is part of collaboration with Electrical and Computer Engineering Dept. and Cardio-Vascular Research Center of the University of Virginia, USA. Three algorithms involving tracking using level set analysis and tracking shapes under non-fronto-parallel viewing were designed and are now being tested by the medical researchers.

Estimation of Cloud Motion Vector

A novel method for finding tracer clouds from weather satellite images was proposed. It is a hierarchical method. First, different features are extracted from the sequence of cloud images and based on these features, clouds are segmented using K-means clustering algorithm. Then considering the coldest cloud segment, potential regions for tracer clouds are identified. These regions are represented by a set of features. These steps are repeated for images taken at three consecutive time instants. Then simulated annealing method is used to establish an association between cloud segments of successive image frames. In this way several chains of associated cloud regions are found. These chains are then ranked using fuzzy reasoning. The method has been tested on several image sequences and in each case it was found to do an excellent job.

Machine Intelligence Unit

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 was recently being done in MIU comprises both the development of these technologies individually and in an integrated (hybridization) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, machine learning, image processing, expert systems, vision, data mining, bioinformatics, 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 soft computing paradigm. They provide the 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 described below.

Research Activities

Pattern Recognition

Genetic algorithms (GAs) with variable number of hyperplanes were used for modeling the decision boundaries for pattern classification. The criterion that is sought to be minimized is a combination of the number of misclassified points and the number of hyperplanes Since such a combination is, in general, ad hoc in nature; therefore the application of multi-objective GAs as the underlying search and optimization strategy is also being investigated. In this regard, a multiobjective GA based classification scheme that incorporates domain specific constraints was developed. The different objectives that are simultaneously optimized are the number of hyperplanes, the overall correct classification of the data and the product of the class wise correct classification scores. The results demonstrate the superiority of the multi-objective scheme over the single objective one for several real-life data sets, including remote sensing images.

A way of incorporating elitism partially in multi-objective GAs was proposed. Its utility in obtaining better strings is under investigation. Its application to the feature selection problem is also being studied.

Image Analysis/Processing and Computer Vision

A computationally efficient and robust image watermarking technique in transform domain was developed. In this technique, two types of image blocks (namely low and mid range blocks) are selected based on the information content of the individual block. Pixels of watermark symbol are then converted into a linear string with pseudo random selection using secret key. Each element of the string is then inserted in the selected image blocks of the cover image so that it does not produce perceptual degradation. Experimental results indicate that the proposed technique is resilient to common external attacks like mean, median and Gaussian filtering, lossy compression (JPEG), cropping, scaling and change of dynamic range of intensity.

Content Based Image Retrieval (CBIR) is another important research area of MIU. An efficient technique for gray tone image characterization using fuzzy geometrical properties, like dominant fuzzy edge points, compactness of the fuzzy edge map (without object-background segmentation of the image) was developed. The performances of such characterization were tested on a variety of benchmark databases like trademark database, Olivetti and COIL picture databases.

A new segmentation based gray-level image compression algorithm was developed. The compression is lossy in nature and provides reasonably good compression ratio with good signal to noise ratio.

Wavelets are used in different aspects of image processing. Different wavelets are being examined for this purpose. Fuzzy wavelets are also under investigation for their flexibility in image compression and different image processing tasks.

A scheme was proposed to generalize the existing gray-scale image enhancement techniques for color images. The scheme is hue preserving and is seen to avoid the gamut problem. A Hough transform based segmentation technique for color images has also been proposed. A method for finding edges in a gray-level image using the properties of the Chi Square distribution has been developed. Its superiority over several conventional edge detection procedures has been established considering several real life images.

A generalized self-organizing multi-layer neural network, incorporating fuzziness measures was designed for multi-level (multi-class) image segmentation. The existing network can handle images having just two classes (object and background), which restricts its applicability to real life images. To remove this restriction, the current approach considers each pixel in the image as being represented by a set of C ($C > 2$) neurons in each layer, which correspond to the C classes into which the image is expected to be segmented. Results of a simulation study using synthetic and real images are seen to be quite satisfactory.

Data Mining and Knowledge Discovery

A new feature similarity measure, namely maximum information compression index for high dimensional data sets was defined. An algorithm for dimensionality reduction using the new feature similarity measure has been developed. It was found to reduce the number of features significantly without loss of information.

An algorithm for data condensation was developed, which apart from condensing the data, also provides a good nearest neighbor search methodology. This algorithm has been found to provide better condensation results than the existing tree based algorithms.

A support vector (SV) machine-based classifier which uses statistical queries was developed. That its performance was better than these of the existing SV learning algorithms, in terms of computational speed was also demonstrated.

Multi-objective GAs were used for mining association rules from large data bases. Each chromosome of the population represents a rule and fitness of rules is measured by using confidence, compressibility, interestingness etc. Genetic operators were also modified in this regard. Investigations are going on to compare the proposed techniques with existing algorithms.

Fuzzy decision tree was designed to extract domain knowledge and encode fuzzy neural network. A new measure was developed to quantitatively evaluate the performance of the decision tree for classification and rule generation. Symbolic clustering technique has been developed to handle non-numeric data. Different clustering validity indices have been extended to the symbolic framework.

An algorithm for discovering repeating substructures from graphical databases was developed. It uses evolutionary programming as the underlying strategy to search for the patterns in the graph that provides the maximum compression. A hierarchical approach is currently being studied.

Genetic Algorithms (GAs)

A specific type of multi-parent recombination, called *univariate marginal distribution algorithm* (UMDA) where allele-wise probability distribution of genes is used to generate a new offspring, was applied to non-stationary function optimization. Results show that such an algorithm can trace the change in environments much faster than the conventional GAs. Multi-criteria optimization is being attempted to be solved by GAs.

A way of pipelining various stages of a GA (called PLGA), incorporating Boltzmann distribution in its selection operator, was formulated. The system (PLGA) has been applied to various functional optimizations and a combinatorial optimization problem (TSP).

A new scheme for incorporating elitism in multi-objective genetic algorithms was developed and is currently being tested. A new algorithm for performing multi-objective optimization with simulated annealing is also being developed.

Fractals and Wavelets

A robust and computationally fast technique for multi-class texture segmentation technique using multi-scale M–band wavelet filter was developed. This was found to be extremely useful for the segmentation of text and graphics parts in unstructured and complex (overlapping text and graphics) document image. 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 and graphics. The method is found to be superior to many existing popular techniques.

Case Based Reasoning

Case-based reasoning may be defined as a model of reasoning that incorporates problem solving, understanding and learning and integrates all of them with memory processes. These tasks are performed using some typical situations, called *cases*, already experienced by the system. Systems based on this concept are finding widespread applications in various decision-making processes, e.g., medical diagnosis, law interpretation where the knowledge available is incomplete and/or evidence is sparse. Various case selection algorithms are being developed in neuro-fuzzy framework. For these purposes, fuzzy indices were defined in terms of weighting coefficients, representing importance of selected cases. These indices are then minimized in connectionist framework in order to obtain an optimal set of cases along with their degrees of importance.

A rough-fuzzy hybridization scheme for case generation was proposed. Fuzzy set theory was used for linguistic representation of patterns, thereby producing a fuzzy granulation of the feature space. Rough set theory was used to obtain dependency rules, which model informative regions in the granulated feature space. The fuzzy membership functions corresponding to the informative regions are stored as cases along with the strength values. Case retrieval is made using a similarity measure based on these membership functions. Unlike in the existing case selection methods, the cases here are cluster granules, and not sample points. Also, each case involves a reduced number of relevant features. The algorithm is suitable for mining large data sets, both in dimension and size, due to its low time requirement in case generation as well as retrieval. Superiority of the algorithm in terms of classification accuracy and case generation and retrieval times was demonstrated on some real life datasets.

Fuzzy Sets, Rough Sets and Applications

An integration of a minimal spanning tree (MST) based graph-theoretic technique and Expectation Maximization (EM) algorithm with rough set initialization was developed for non-convex clustering. EM provides the statistical model of the data and handles the associated uncertainties. Rough set theory helps in faster convergence and avoidance of the local minima problem, thereby enhancing the performance of EM. MST helps in determining non-convex clusters. Since the MST is constructed using only the means of the Gaussians, obtained by the EM and approximating the actual data set, time required is much less. The problem of segmentation of multi-spectral satellite images is addressed under this framework. This involves thresholding of individual bands based on fuzzy correlation in order to provide the granules. A rough-self-organizing map was also developed incorporating domain knowledge into the network parameters through rough set rules.

INDIAN STATISTICAL INSTITUTE

Physics and Earth Sciences Division

Geological Studies Unit

Research in the Geological Studies Unit has been focused on (a) Tectono-sedimentary evolution of the Proterozoic cratonic basins, namely the Pranhita-Godavari (PG), Chattisgarh and Cuddapah basins and tectonothermal evolution of the Eastern Ghats belt; (b) Sedimentation, paleoclimate, vertebrate fossils and tectonics of the late Paleozoic-Mesozoic Gondwana basins, mainly the Satpura basin. These basins are important for their hydrocarbon and/or other mineral potential. Topical issues bearing on deformation mechanisms in the upper crust have also been pursued. A research programme on Surface, Colloid and Environmental Sciences has also been supported.

Research Activities

Proterozoic cratonic basins

PG valley basin

The geological mapping in the eastern outcrop belt of the PG Valley was continued to reconstruct the lithostratigraphy and to elucidate regional stratigraphic relationship between major lithological groups. The lithilogical succession of the mixed siliciclastic-carbonate-pyroclastic assemblage was established around Bijjur in the northwestern part of the outcrop belt. Comparison of the Bijjur succession with the succession of the Somanpalli Group around Somanpalli further down southeast, is expected to provide a comprehensive regional stratigraphic picture. An angular unconformity has been proposed between the Somanpalli Group and the overlying Albaka Group. The lithologic succession in the Bijjur-Somanpalli belt has a major component of shale, bedded chert, pyroclastics and graywackes. The lithologic assemblage bears the signatures of deposition in a mobile belt in contrast to the stable platformal associations of the Pakhal and Penganga Groups, developed primarily in the western outcrop belt.

Chattisgarh basin

The lithological mapping in the northern part of the eastern Chattisgarh basin was completed and a complete stratigraphic succession reconstructed. Multiple flows of felsic welded tuff have been identified in the upper part of the succession. The welded tuffs are separated by thin intervals of red shale, and the tuff-shale interval points to a major episode of rifting. Welded tuff from one of the flows has been dated at 950 Ma. The tuff-shale interval is unconformably overlain by a shallow marine sandstone with a basal conglomerate containing pebbles of welded tuff and deep water limestone that occurs at a lower stratigraphic horizon. The unconformity is being reported for the first time.

Palnad subbasin and Nallamalai Fold Belt

Late Paleoproterozoic-Mesoproterozoic antiquity of an early phase of tectonic convergence along the eastern margin of south India and involving the Nellore Schist Belt and the adjoining Cuddapah basin leading to the evolution of the Nallamalai fold belt, was established through a new analysis.

It was shown that the tectonic shortening in the Palnad subbasin (northeast Cuddapah) was partitioned into top-to-west thrust shear, flexural folds and cleavage development in the Kurnool Group, under overall E-W contraction. A foreland style continental shortening related to convergence of the Eastern Ghats terrane and the East Dharwar-Bastar craton during early Neoproterozoic (Greenvillian) and/or later Pan-African rejuvenation is indicated.

Recent field mapping in parts of Cuddapah district indicated westward thrusting of the Nallamalai rocks over the Kurnool Group and large steep E-W transverse faults, comparable to tear faults separating blocks of unequal thrust advance. New work has been undertaken to establish the extent and mechanism of footwall deformation in the Kurnool rocks west of the thrust line at the western margin of the NFB.

Eastern Ghats Belt

Isotopic evidence of high temperature dehydration melting and decompression in a clockwise P–T–t path was described from the granulite suite of Paderu, Andhra Pradesh. Evidence of rapid exhumation in the western marginal segment of the Eastern Ghats Orogen was documented from the shear zone at the western margin. U-Pb isotopic evidence of polymetamorphism was documented from the northern sector around Jenapore. New field structural evidence has been used to show that the Koraput Alkaline complex was emplaced in a pull apart structure. It has also been demonstrated that the Rairakhole Alkaline complex is a product of crustal melting as evidenced by Sm-Nd isotopic ratios.

Late Paleozoic-Mesozoic Gondwana basins

Vertebrate Palaeontology

A new fossil site at the western part of the Satpura basin was discovered in the red mudstone of the Denwa Formation. This is the first record of fossil vertebrates from the western part of the Satpura basin. A large number of bones of an archosauromorph have been collected from this new site. The tentative identification of these bones reveals that this may be a new rauisuchid, which is not yet recorded from the Denwa Formation. The Denwa Formation has been dated as early Anisian on the basis of recovery of a faunal assemblage from the eastern part of Satpura basin only.

A thorough analysis of terrestrial tetrapods of India through geological ages was undertaken.

Gondwana basin tectonics and sedimentation

Significant progress was made in the studies on Gondwana basin tectonics and sedimentation. The kinematics of the Gondwana basins of peninsular India was studied on the basis of fault and lineament analysis and experimental simulations with sand box models. The Gondwana basins formed in response to a regional bulk tectonic movement resulting in lateral extension roughly along the present day E–W direction. The basins can be grouped into two genetic types: extensional rift basin and strike-slip basin. The Satpura basin owes its origin to strike-slip movement.

Marine vertebrate fossils have been recorded from the Talchir rocks of the Satpura basin, and nature of glaciation depositing the Talchir rocks has been documented. Sedimentological signatures of marine sedimentation have also been obtained from the Talchir rocks as well as the overlying Barakar strata. The palaeogeography of the Satpura basin at different phases of its evolution has been reconstructed.

On the basis of facies analysis and analysis of palaeocurrent data, the Triassic Denwa Formation was recognized as a deposit of ephemeral streams traversing semi-arid, vegeted country. Sheet-flood dominated, and low-gradient muddy alluvial fan has also been recognized in the Denwa Formation.

Surface, Colloid and Environmental Sciences

"Physicochemical Studies of Self-organizing systems with special reference to Micelles and Microemulsion/ Reverse Micelles" were undertaken as a model system for the development (formulation), characterization, transport behaviour and uses of new single and mixed surfactants microemulsion systems.

Solubilization of water and aqueous NaCl (of different concentrations) in mixed reverse micellar systems with reference to anionic-nonionic, cationic-nonionic and nonionic-nonionic surfactants in three different types of oils (cyclohexane, isobutyl benzene and isopropyl myristate) were investigated. Synergism in solubilization of water and aqueous NaCl has been observed in some combination of surfactants and found to be dependent on surfactant type and component, solvent (oils) and optimum concentration of NaCl. An optimum concentration of NaCl has been developed for some systems where solubilization capacity reaches a maximum. The thermodynamic parameters ($\Delta \bar{G}^{0}_{t}$, $\Delta \bar{H}^{0}_{t}$ and $\Delta \bar{S}^{0}_{t}$) of these solubilization processes were determined

from the solubilization curves (ω vs. temperature) at different temperatures. The mechanism of the solubilization has been explained on the basis of inter-droplet interactions, molecular volume of oils and energetic parameters.

The microstructure of these reverse micellar systems was elucidated by conductivity measurements. The temperature-induced percolation in conductance (abrupt increase in conductance) in oil continuum, more precisely the percolation threshold temperature T_p for mixed reverse micellar systems were found to be dependent on the water content (ω), surfactant blends (content of second nonionic surfactant) and type of oil. Additives (NaCl, NaC, urea) play an important in order to ease or hinder/ block the percolation process and consequently alter the T_p.

The activation energy of percolation (E_p) was estimated for all these systems (in absence and presence of additives) and found to be dependent on ω content of nonionic surfactants and type of additives. The percolation process for these systems has been interpreted with the help of E_p values.

Structural information about the microemulsion systems stabilized by anionic AOT, nonionic (B-35) and (AOT+Brij-35) and three different oils (cyclohexane, isopropyl myristate and clove) was obtained from the viscosity measurements. The droplet structure has been observed to be dependent on both oil and surfactants and its compositions. The viscosity of these microemulsion systems [AOT, Brij-35 and AOT+Brij-35 with 1:1 (w:w)] at different temperatures was measured to underline the thermodynamics of the transport process using Frankel-Eyring equation.

Physics and Applied Mathematics Unit

Research Activities

Physics

Condensed Matter Physics

Application of field theoretical techniques to the study of Quantum Hall Effect (QHE) and High Temperature Superconductivity (HTS) is of great interest. Recently, a model has been proposed for the pairing in HTS which has explained the phase diagram of it through renormalization group equations.

Very recently, the investigation of the problem of quantum Hall skyrmions in the framework of O(4) non-linear sigma model showed the existence/non-existence of skyrmions in polarized, partially polarized and unpolarized quantum Hall states. The estimation of the size and energy of the skyrmions, in this scheme, were also carried out. Besides, the study of Magnus force from the topological properties of the excitations of the respective system (QHE or HTS) has shown that it is generated by the chirality of the system and is associated with the Berry phase.

Theoretical Condensed Matter (Few electron systems having parabolic confinement and its dynamics in presence of a magnetic field) and problem of modelling a quantum-dot, have also been undertaken.

Classical Optics

Research work has been undertaken to develop a proper physical understanding of the generalized Snell's law; and for a comprehensive understanding of the particle size distribution from the extinction spectra produced by them in the inverse scattering problems of classical optics, based on numerical experiments.

Foundation of Quantum Mechanics

Bell's inequality violations and the concept of non-locality raised lot of interest in recent time. The crucial role of local non-commutativity of operators in Bell's inequality violation has been studied for photonic field states. It has raised new interest towards understanding the foundational problem of quantum mechanics.

Physics at Planck Scale

The discrete structure at Planck Scale and the continuum space-time poses new challenge to the physicist community. Kind of pregeometric notion has been studied using the concept of dynamic networks, quantum graphs and set of fuzzy lumps which may solve the riddles behind Planck Scale. This has great impact on the future researches in theoretical physics.

The Non-Doppler wavelength shift and Dynamic Multiple Scattering Theory

Recent laboratory experiments verify the predictions of dynamic multiple scattering theory as developed by Roy et. al. This has been developed using Wolf's idea of correlation induced shift by the turbulent and/or inhomogeneous medium. It has great impact on the quasar astronomy and for cosmological redshifts. The data from quasar astronomy are under investigation to check the linearity of Hubble relation as well as to estimate the age of the universe.

Quantum Information & Entanglement

An important problem in quantum information, viz, connection between teleportation of entanglement and entanglement of the required channel has been studied and this study is now being extended to four qubits joint entangled state which also opens the possibility of the study of distillable entanglement.

The study of distinguishability of orthogonal entangled states is a very rich area and an extensive study has been undertaken in this regard. This study opens up the possibility of finding the distillable entanglement of a class of states and dealing with the fundamental problem of irreversibility of entanglement processing. The study of the optimal cloning fidelity for various set of states using no-signaling theorem has been undertaken.

The nonlocal properties of generic N-dimensional bipartite quantum systems were investigated. A complete set of invariants under local unitary transformations was presented. It has been shown that two generic density matrices are locally equivalent if and only if all these invariants have equal values.

The exact remote state preparation protocol of special ensembles of qubits at multiple locations has been discussed. Generalization of this protocol for higher dimensional Hilbert space systems for multiparties has also been presented. It has been shown that the crucial feature is the use of multiparticle measurement and the use of dark states as a quantum resource.

Quantum Field Theory

Investigations in the Non-Commutative (NC) quantum field theory have continued. A new expression for the local form of the axial anomaly, which is consistent with the Seiberg-Witten Map has been derived. The integrated form of the anomaly reduces to existing results. It has been shown that in the Hamiltonian formulation, non-commutativity in the open string end points connected to D-branes, in the presence of a background two-form field, arises from a careful consideration of the boundary conditions. These works have been done in collaboration with Dr. R. Banerjee and Dr. B. Chakraborty of S. N. Bose National Centre for Basic Sciences, Kolkata.

In $2+1$-dimensional NC spacetime, the duality between self-dual model and Maxwell-Chern-Simons model has been analysed, emphasizing the role of gauge invariance. Bosonization of fermion models in the large fermion mass limit in NC spacetime has also been discussed. A fully covariant quantization of the spinning particle model has been performed and its connection to the NC spacetime has been demonstrated. In this connection, an alternative interpretation of the Seiberg-Witten Map has also been proposed. A relativistic and (classically) conformal invariant field theoretic model for the NC spacetime has been constructed.

The study of CP^1 model in $2+1$-dimensional NC space-time has been undertaken.

Quantum Mechanics

A Lie algebraic approach to effective mass Schrödinger equations has been given. In particular, the *SU (1,1)* algebra has been used both as a spectrum generating algebra and potential algebra to obtain exact solutions and isospectral Hamiltonians.

A general procedure for determining possible (non-uniform) magnetic fields such that the Pauli equation becomes quasi exactly solvable (QES) has been presented using the close connection between super-symmetry and QES systems with underlying SL(2) symmetry.

Coherent as well as super coherent states for some quantum mechanical systems have been given using Gazean Klauder approach.

With the help of first order intertwining operator isospectral partner potentials of complex PT invariant potentials have been obtained. Work is going on on second order intertwining operators and their roles in pseudohermicity.

Theoretical Plasma Physics

Solitary waves and double layers in magnetic and nonmagnetic plasmas are areas of present research. Recently solitary wave structures in relativistic Dusty plasma are being studied to investigate relativistic effect and drift ion velocity.

Nonlinear Physics

Nonlinear instabilities in dissipative physical systems maintained far from equilibrium often lead to a transition from isotropic to anisotropic structures. Selection of these dissipative structures in soft-condensed matter is of current interest. A model for studying interaction among competing instabilities in a hydro-dynamical system has been constructed. The system reveals interesting dynamics of the pattern dynamics. Quasi-periodic waves at the onset of thermal convection is a new finding.

High Energy Physics & Heavy Ion Physics

Analyses of the oncoming and latest RHIC-experiments at BNL, USA have been continued with the help of a new approach. The approach is seen to be extremely efficient in modelling the biggest chunk of data in a few significant sectors, though the model is to be tested with data in some other parallel sectors as well for its confirmation and vindication.

Study on a Deformed Hilbert Space

Phase operator and corresponding phase distribution are being used to study phase fluctuations in various matter-field interactions.

Interacting Fock Space

Kerr states, even and odd coherent states and their phase fluctuations are being studied in this space.

Fluid Mechanics & Applied Mathematics

Basic Fluid Flows

Spin coating technique is generally used in microelectronics industry to coat the photoresists on silicon wafer. To understand the physical process involved in coating mechanism and the respective effects of the physical parameters few theoretical models are being studied.

Hydrodynamic Stability and Waves

Waves that form on the surface of a thin film flowing down an inclined / vertical plane have dramatic effects on the rate of heat and mass transfer. For designing better quality of heat exchangers and condensers one needs the knowledge of wave characteristics and their stability region. Objective of this field study is to know how wave characteristics change due to flow rate, angle of inclination etc.

Dynamical Systems & Chaos

Modelling various physical problems by dynamical systems helps in capturing underlying mechanism of the bifurcation involved. Chaotic competition between wavy-rolls and squares in zero-Prandtl-number connection has been studied (to show that) the route to chaos is self-turned intermittency directly from conductive state.

Blood flow in the Cardiovascular system

Adomian's decomposition method has been applied to two models. The first model is to study the pulsatile flow of blood in a constricted tube and the second one is to investigate the effect of a magnetic field on the steady flow of blood in arteries.

Besides the above models, the computation on the flow of Bingham fluid through a circular tube of non-uniform cross-section is in progress and the investigation of convergent-divergent channel flow by decomposition method is also going on.

Nonlinear Problems of Laminar & Turbulent Flows

Several problems of viscous incompressible fluid flows are of high interest from both theoretical and practical points of view. Such flows are generally governed by the nonlinear partial differential equations. Similarity method and similarity transformations, obtained from group theoretic consideration have been applied to some two-dimensional boundary layer flows of both Newtonian and non-Newtonian fluids. It has been proposed that such procedures may also be extended to some homogeneous turbulent flows. Besides, models based on a novel energy-cascading mechanism are to be constructed for turbulent flows through pipe and channel and as well as flat-plate boundary layer under different conditions. As of general interest, effects of feed-back control on some dynamical systems are included in the present scheme.

Water waves, Integral equations, Integral transforms, Electromagnetic waves

Water wave scattering problems involving obstacles in the form of thin circular and elliptic plate have been investigated by employing hypersingular integral equation formulations. Scattering of electromagnetic waves by thick iris in a waveguide has been studied by using first and second kind integral equations. Also, the hybrid Fourier integral transform has been generalised and applied to a wave scattering problem in a two-fluid region.

Interdisciplinary Research

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

Flume experiments with five beds of heterogeneous sediment mixtures having different values of bed roughness were conducted in a closed circuit laboratory flume specially designed at Indian Statistical Institute, Kolkata. The results show that for fixed height and velocity the amount of suspension concentration increases up to a certain value with increase of bed roughness and then decreases with further increase in bed roughness. This

indicates depletion of concentration in suspension due to increase of coarse sediment in the bed. Some sort of 'critical bed roughness' together with sediment entrapment acting on the sediment beds prevents the sediment particles from lifting into suspension from the beds. Mathematical models for computation of actual amount (gm/l) and size distribution of suspended materials over different sediment beds, based on diffusion equations of sediment and water, have been developed. Computed results compare well with the observed values of actual amount and grain size distributions comprising the wide range of grain sizes.

Environmental Diffusion

Numerical simulations on the dispersion of dissolved and suspended pollutants in steady / oscillatory, laminar / turbulent flows though conduits in presence of boundary absorption have been carried out. This research has been primarily motivated by the practical importance of basic scientific problems in predicting dispersion of passive tracer molecules released in a pulsating blood flow, and pollutant materials in rivers and estuaries. In order to control contamination in a stream or atmosphere and to predict levels of accidental pollution, an understanding is required of the levels at which a stream is capable of transporting and dispersing pollutants.

Multivariable system and Control theory

The objective of this project is to develop computational methods for analysis, design and development of multivariable control systems. Works pertaining to design observer for matrix second order system, modelling and analysis of dynamical systems, and digital and adaptive control systems have been contemplated.

Biological Sciences Division

Agricultural Sciences Unit

Research Activities

Studies on sustainability criteria in rainfed eastern plateau area

Field trials undertaken during this period established low input appropriate technologies in subsistent farming in relation to crop management and increasing soil health through integrated nutrient management practices. The improved low input technologies are being diffused to farmers' field through 'on farm' trials with the objective to establish and popularize the sustainable cropping system in study area.

Rice area characterization using satellite imagery and geographical information system tools.

Rice is the main crop in the eastern India region and cultivated in rainfed situation. The distribution of rainfall in this region is also highly variable over time and space. This variability, together with high soil percolation and runoff rates, has resulted in high variability in rice productivity. To minimize the uncertainties associated with rice farming and to induce sustainability in rice agriculture in the region, rice area characterization will help to identify the appropriate time and space for rice cultivation and thereby will increase the productivity. Point based rainfall data have already been converted into layers by using a series of GIS software and natural resource inventory will be carried out to get a clear picture of the area.

Studies on the ecophysiology, community structure and biomass estimation of mangroves, and biology, conservation, propagation and utilization of palms.

Mangroves are specialized woody halophytic economically important plants, which grow in the littoral zones of the tropical world. The vegetation pattern of the 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. Forest ecology is the study of distribution, abundance and productivity of forest organisms and their interactions with each other and the environment Forest Eco-physiology provides a basic understanding of the environmental controls behind the distribution, abundance and productivity of forest tree species. In view of these, certain physiological, biochemical and ecological investigations have been carried out on some true mangroves of the Sundarbans to find out their community structure and biomass production, and adaptive status against salt stress. In addition to mangroves, the palms remain one of the most economically important groups of tropical plants, a major source of food and raw material that remains under-explored. Being a very hardy tree, palmyra, wild date and edible date palms have been introduced in dry semi-arid soils in the Giridih Farm of ISI to study their physiology, propagation, and utilization aspects.

Studies on insect pest olfaction

Using neuro-behavioral paradigm, few bio-repellents have been developed against stored grain pests. This work was done in collaboration with the Department of Biochemistry, Calcutta University. A field trial of these bio-repellents was conducted with the help of West Bengal State Seed Corporation and the bio-repellents were found to be active for two months. Using volatiles from *Parthenium sp.*, a bio-repellent is in the process of development, active against the most damaging insect pest of Mustard crop, Mustard Aphid. Further trials are necessary before the bio-repellents are taken to the farmers' field.

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

The largest genus *Calamus* of rattan palms has 52 species in Indian flora. Northeast Himalaya is a major centre of their distribution. The other rattan palms are *Korthalsia, 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. It is evident that the cane species, of which the golla (*Daemonorops*) is endemic to the northeastern region, are becoming increasingly rare due to unsustainable harvesting 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 the Assam University.

Externally Funded projects

Three externally funded projects were in progress during this period. They are :

Researchable constraints to the use of forest and tree resources by poor urban and peri-urban households in developing countries

This is a collaborative project between Indian Statistical Institute and the University of Reading, U.K.

Rice based cropping system studies in rainfed regions of eastern Indian plateau

The project is funded by the International Rice Research Institute (IRRI), Manila. This is also a collaborative project between Indian Statistical Institute and the IRRI, Manila, Philippines.

Work on Abiotic and Biotic Stress response in Jute Plant

This is a collaborative project between the Central Institute for Jute and Allied Fibres (CRIJAF), Barrackpore, West Bengal, and the Indian Statistical Institute.

INDIAN STATISTICAL INSTITUTE

Anthropology and Human Genetics Unit

The Unit has been conducting research in various areas of human biology and human genetics. Many of the recent findings made by this Unit have won national and international acclaim. Members of this Unit have also been engaged in teaching within ISI and also in various Indian universities.

Projects Undertaken

Internally funded Plan projects

Modernization and Cardiovascular Health in the Sikkim Himalaya

Family data on blood pressures, blood glucose, blood lipids, anthropometrics, behavioral traits and dietary practices were collected from among the Bhutias inhabiting Gangtok and its neighborhood. 40 extended families were selected each of which had at least one member, aged 25-35 years, with essential hypertension.

Gene-Environment Interaction in Oral cancer

Polymorphisms in CYP1A1 and CYP2E1 were investigated in leukoplakia patients and matched controls. It was observed that a polymorphic site (DraI) on CYP2E1 gene might modulate the risk of oral precancer among tobacco smokers. In "anti-tuberculosis drug (ATD) induced hepatotoxicity" project, polymorphisms in NAT2 gene were investigated in small number of patients and controls. It was observed that slow/fast acetylation capacity of NAT2 gene could not modulate the risk of ATD-hepatotoxicity. But more patients should be studied for further analysis.

Growth as a mirror of conditions of society

Twenty-one body measurements from 1187 Bengalee boys aged 7-16 years were completed along with their socioeconomic and demographic data. Analyses of data were completed. Taking of 11 body measurements (along with maturational data) from 177 girls aged 7—16 years was completed.

Population structure and microevolution – the effect of mating patterns on genetic differentiation among the Adi-Pasi tribe

Household demography and information about the marital patterns of the population were collected during the fieldwork in March 2002 in seven villages of Adi-Pasi tribe in central Arunachal Pradesh in northeast region. The data on inter village and inter clan marriage patterns were analyzed. Apart from the four villages several people live near Pasighat town. It was observed that a majority of the marriages are regulated within the 8 surnames among Adi-Pasi. And several other marriages are contracted with other subgroups of Adi group, especially Adi-Padam, Adi-Minyong and others.

Health of Mother and Child

This project has been completed.

Health of the Tibetan Refugees in Exile in India.

Demographic characteristics of Tibetan households were collected from 300, 91 and 82 households, respectively, from Chandragiri in Orrisa, Delhi and Bylakuppe in Karnataka. Detailed clinical and anthropometric data were collected from 274 (adult male: 47, female: 60 and children, male: 69 and female 98) individuals.

Origin and genetic composition of the Lyngngam.

All the major Meghalaya tribes (9 in total) were studied and typed for mtDNA, Y-based and autosomal markers. The results are likely to throw light on the possible origin of the Mon'Khmer tribes of Meghalaya and particularly in the perspective of NE Indian corridor for initial migration of people into the Indian sub-continent. This project is now extended to cover about 30 other austro-asiatic tribes of India and to decipher their status in the peopling of India.

DNA polymorphisms in the castes and tribes of Andhra Pradesh

Typing/sequencing of DNA of about 35 populations for mtDNA, autosomal and Y-based markers including the SNPs were completed.

Health and Disease : Comparison between two ecological settings

The objective of the project was (1) to assess the health status of the Meiteis and Bengali speaking Assamese group who are inhabiting closely for several years, (2) to evaluate the relative effectiveness and limitations of their traditional management systems regarding health and disease, (3) to determine the microenvironmental risk factors including socioeconomic and cultural factors affecting health. The data on mortality, morbidity, anthropometry, haemoglobin level on about 300 individuals have been collected to satisfy objective 1. Some qualitative data including the health and hygienic practices and traditional belief and real-life practices in times of crises have been collected on about 350 individuals of both sexes.

Genetic Epidemiology and Diversity in Indian Populations

About 50 DNA markers spanning mitochondrial and autosomal genomes were studied in samples of individuals drawn from about 40 ethnic groups of India. The statistical analyses of these data have added to the understanding of the process of peopling of India.

Biochemistry Unit

Non-Northeast Programs

Cervical Neoplasia Host Genetic Factors for High Risk HPV-Infection

Many women are exposed to high-risk HPV (major etiologic factor of cervical cancer, which is the foremost cancer among Indian women) 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, such as HLA types, p53 polymorphism at codon 72, etc, have been investigated in order to understand the role in the pathogenesis of HPV related cervical cancer and precancerous lesions. Reasonable data on both factors have already been generated. p53 polymorphism shows that proline/proline homozygous women are more at risk for the development of cervical cancer at early ages over the arginine/arginine or proline/arginine polymorphic varieties. Such data is currently limited in India and therefore, will contribute towards the prevention of cervical cancer. Some of these data have been published in an international journal in 2002 and some have been submitted for publication.

High Risk HPV-Infection and the Natural History

Muslim women are known to have lower incidences of cervical cancer and/or HPV infection. An attempt has been made to determine association between the oncogenic HPV16/18 infections and abnormal cytological lesions along with demographic and other attributes in Indian Muslim women (n=478) and compare the data with that of their Hindu neighbours (n=534) in north & south 24-Parganas, West Bengal. The data show that these Indian Muslim women are equally susceptible to HPV16/18 infection and for the development of abnormal cytology and paucity exists in epidemiological data on the Indian Muslim women. The data further justifies the need for screening all women for cervical cancer and the screening sshould include oncogenic HPV

testing. A cost-effective screening strategy for cervical cancer using HPV-testing and Pap smear has been proposed and published in an international journal during 2002

Northeast Programs

HPV infection and Cervical Cancer in the Northeastern States of Manipur & Sikkim

In Manipur approximately 43% oncogenic HPV-infection is present in the cancer samples and 5%, in the normal samples. Abnormal cytology is only 1.5 % in the population. Data from Sikkim show that 13.3% of the screened women display abnormal cytology, whereas the HPV infection is 9-10%. Human resource development and awareness campaigns have been important parts of the study. A student from Manipur has been undergoing training on the program. A workshop in Manipur and several lectures including a Press Conference (organized by the Government of Sikkim) in various parts of the State have been organized in order to create awareness among the Health/Social workers and public.

Externally Funded Project

A project on low cost alternative to Pap test for screening cervical cancer/abnormality has completed its Phase I study and was renewed for Phase II by the Department of Science & Technology, Government of West Bengal for 2002-2003. The objective is to find out whether dilute (4-5%) acetic acid can be used for down staging in identifying cervical lesions. The work is in progress

The Indian Council of Medical Research has funded a project on the feasibility of screening for cervical cancer in the tribal women (in Bastar, Chhattishgarh). One hundred fifty three women are already screened with Pap smear and HPV-oncogenic types. That these totally unexplored groups of women have poor reproductive health status was evident even at this early stage of investigation. The work is currently in progress.

Biometry Research Unit

Research Activities

Studies on Hepatoprotective activity of neem ((*Azadirachta indica*) leaves

Efficacy of neem (*Azadirachta indica*) as a drug with special reference to its hepatoprotective activity is being studied. It has been observed that neem leaf extract not only possesses significant blood sugar lowering, antiserotonin, antiinflammatory, hypotensive, antifertility and hypolipidemic activity but also has significant hepatoprotective activity against paracetamol induced hepatic damage in rats. Effects of neem leaf extract on some biochemical and haematological parameters and histological observations of liver reveals that hepatoprotective activity of neem leaf extract may be due to its antioxidant property. Further studies are in progress to elucidate the possible mechanism of hepatoprotective action of neem leaves and chemical constituents responsible for this activity.

Our ultimate goal is to develop a simple, precise, inexpensive and indigenously available hepatoprotective drug so that people of our country who are suffering from liver ailments can make use of the drug. If successful, this research will result in an effective drug indigenous and inexpensive for the treatment of liver ailments.

Chemistry Unit

Research Activities

Status of Molybdenum (Micronutrient) in Surface Soils of Hills and Foot Hills of West Bengal

Micronutrient element like molybdenum is normally present in the soil in an oxidized form, molybdate

of calcium and other metals. We have studied the assesment of total and bio availability of molybdenum spectrophotometrically of two groups of soils namely hill soils and foot hill soils of West Bengal. The hill soils comprise Algarh, Pedong, Kalbung, Lava, Mirik and Kalimpong, while the foot hill soils comprise Jalpaiguri, Falakata, Moynaguri, Toofanganj, Dinhata and Coochbihar.

Our findings show that the total molybdenum in hill soils and foot soils ranged from 0.18pppm-0.25ppm and 0.37ppm-0.81ppm whereas bio availability of molybdenum in both the groups of soil is in extremely negligible amount (not detectable). The soil in this region is highly acidic with pH value ranging between 4.3 and 5.6. Soils of the hill and foothill experienced above average rainfall and low temperature than other parts of West Bengal.

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.

Embryology Research Unit

Research Activities

Studies on Marine Plankton Ecology

Algal blooms have several adverse effects on the ecosystem. From the field collected samples from Digha-Talsari-Sankarpur area of the district of Purba Medinipur, West Bengal, it has been observed that there is high abundance of zooplankton populations and less amount of Toxin producing plankton (TPP) present in the collection zones nearer the riverside. But the situation is reversed in the collection zones farther from the riverside. A delay induced stochastic differential equation model has been proposed based on the real life observations. The investigation suggests that both TPP and control of artificial eutrophication may act as bio-control for the termination of planktonic blooms.

Studies on Epidemiology

A suitable regression model for the occurrence of malignant malaria in Kolkata Municipal Corporation area has been proposed by considering the important environmental and social factors. A basic mathematical model on malignant malaria with environmental fluctuations has been considered to compare the qualitative nature of the proposed regression model. It has been concluded that social factors may be used for proper program implementation in the case of disease outbreak.

A Technique for Finding Maximum Harvesting Effort in Fishery Problem

Exploitation of biological resources and the harvest of different available and required species are commonly practiced in fisheries, forestry and wild life management. Estimation of maximum harvesting effort has a great impact on the economics of fisheries and other bio-resource harvesting enterprises. A technique for finding the maximum harvesting effort in fluctuating environment has been developed in a two species competitive system, which shows that under realistic environmental variability the maximum harvesting effort is less than what is estimated in the deterministic model. This method also enables one to find out the safe regions in the parametric space for which the chance of extinction of the species is minimized. A real life fishery problem has been considered to obtain the inaccessible parameters of the system in a systematic way. Such studies may help resource managers to get an idea for better management of the system.

Plant Chemistry Unit

Research Activities

Plant Chemistry aimed towards the development of suitable ecofriendly technologies with natural resources of plant origin keeping in view the careful protection of the environment. Study areas are concerned

with environment, ecology and adaptation. Research was focussed on environmental awareness, rural upliftment, ecological diversity, mobilization of indigenously available resources, agroclimatic adaptation of various crops of immense potential and microbial enzyme as a tool for applied microbiology and biotechnology.

Chemical Characterization and Utilization Potential of Plant Origin Wastes with Suitable Technologies and Enzyme Biotechnology

Plant origin wastes are the most abundant renewable organic resources on earth and favourably distributed in a country like India with its vast natural resources. A detailed investigation was undertaken on chemical characterization of various plant origin wastes from agricultural fields, social forestry circles, etc. For profitable utilization of the wastes various mechanical, chemical and microbiological technologies were adopted.

Microbial diversity was examined with the routine isolation, identification characterization and active participation of enzyme producing microbes.

Through the course of investigation a large number of cellulolytic microorganisms were screened from different ecological niches and were identified on the basis of their morphology and performance in standard physiological and biochemical tests. Most of the microbes were proved to be efficient cellulase producers as indicated by their CMCase, FPase and β-glucosidase activity. Fermentation trials and saccharification studies with potential cellulolytic strains resulted in the formation and simple sugars, which were further exploited for the production of antibiotics, acids and enzyme. The potentiality of lignocellulosic wastes as substrates for bioconversion by cellulolytic microorganisms was established. It was an eco-friendly approach in the abatement of pollution that led to the conversion of agricultural wastes into useful products, thereby reducing health hazards.

Relationship between Aquatic Weed Growth and Water Quality in Ponds

Aquatic macrophytes, a vital component of our village ecosystem, were studied for their role, if any, in water quality assessment in ponds. Cheaper and quicker methods of water quality assessment are needed in our country where high rates of pollution demands the need for continuous monitoring of our water bodies. Baseline data on aquatic weed growth and water quality in two local ponds were collected at monthly intervals for more than three years. Preliminary analyses reveal that an increase in species number is indicative of nitrogen enrichment of waters and the presence of a submerged plant, *Vallisneria spiralis*, indicates water clarity in ponds even when the water has a high phosphorus content. Thus, aquatic plants could prove to be very useful for rapid assessment of water quality as opposed to chemical methods of analysis, which are more expensive and time consuming.

Moreover, the excess biomass of another aquatic plant, the duckweed (*Lemna minor*), was successfully used for making compost, an organic fertilizer, which was further used in trials on marigold plants. The flowers of marigolds grown on the prepared compost not only were bigger in size when compared to those grown on regular manure but also had a longer retention time.

Yield Performance of Sugar Beet (Beta vulgaris L.) Varieties at Different Growth Stages

In the year under review three new sugar beet (*Beta vulgaris* L.) varieties, seeds namely FD CR 0018 (resistant to cercospora), FD RH 0111 (moderately resistant to Rhizomania) and FD 0133 (no particular resistance) were ssupplied by Florimond Desprez, France. All these three sugar beet seeds were sown in mid November of 2002. As in the previous year five nitrogen (N) doses (0, 40, 80, 120 and 160 kg/ha) with three potassium (K) doses (50, 100 and 150 kg/ha) and with fixed phosphorus (P) dose of 60 kg/ha were applied in the experiment. These fifteen treatment combinations (5 N X 3 K) with three replications were put under Factorial Randomised Block Design (FRBD) experiment. Data were collected for various yields in 20 day intervals starting from 75 days of the crop and up to 155 days. It has been observed from the experiment that variety FD CR 0018 gave highest root yield of 55.25 ton/ha at 155 days of the crop growth with N160 and K100 kg/ha treatment combination at 155 days of the crops. Highest sugar yield of 10.65 ton/ha was given by the same

varieties at the same growth stage. Regarding leaf protein (LP) variety FD 0133 gave maximum yield of 525.25 kg/ha at 115 days of the crop growth stage with N160 and K50 kg/ha treatment combinations.

Social Sciences Division

Economic Research Unit

The main areas of research undertaken during the past year are: econometric methods, applied econometrics, agricultural economics, welfare economics, game theory, international economics, development economics, macro economics, industrial organisation, regional economics, financial economics and environmental economics. The results of these researches have been published/accepted for publication in reputed national and international journals like Review of Development Economics, Development Policy Review, European Economic Review, Journal of Income Distribution, Keio Economic Studies, Journal of Policy Modeling, Games and Economic Behaviour, Economic Theory and Journal of Economic Inequality.

A "Discussion paper series" has recently been started to provide an overall view of the Unit's current research activities. These papers are posted at http://www.isical.ac.in/~eru/.

The scientists of E.R.U. have been teaching various courses in economics and econometrics for the B.Stat. (Hons.), M.Stat., I.S.E.C (regular and specialization) and M.S.(Q.E.) programmes. Six research fellows have been working for their Ph.D. under supervision of members of the faculty of E.R.U. A faculty member has been serving as an external evaluator for the World Bank Projects and another as a member of a committee, constituted by the State Government, to study the financial programme of the State Government for the 10th Plan period.

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

The externally funded project 'Environmental Management Capacity Building Assistance Project: Environmental Economics Component', a project of five years' duration, was undertaken by the Ministry of Environment and Forests, Govt. of India, with assistance from the International Development Association of the World Bank. The project is in the final year of its duration and will terminate in June, 2003. Under this project a number of training programmes, workshops and seminars have been organised during the last five years. The project has helped improve the infrastructural facilities. The project has also enriched the library as a large number of books on Environmental Economics and related topics have been procured using the library grant available under the project.

The project 'Solid Waste Management in Baranagar Municipal area' was undertaken as a part of the externally funded project on Environmental Management mentioned above. This project aims at estimating the quantity and the nature of composition of garbage generated collectively by households, commercial units, markets, hospitals, etc. in the Baranagar Municipality area. The project also tries to assess the extent of awareness of people and their attitude regarding the generation and disposal of household garbage in their neighbourhood. A sample survey of households, commercial units and markets designed for collection of necessary information has already been completed.

The work for the plan project 'A fresh look at agricultural price statistics with special reference to West Bengal' has been completed. The report is now being written. This project critically reviews the methodologies used for collection and compilation of official price statistics, as the publications of these statistics by different organs of the government for the same period show a number of discrepancies. In this connection, the role of traders in price formation in some agricultural markets of West Bengal has also been studied.

The plan project 'Economic problems of illiteracy', which started in 2001, is a study relating to the North-East India region. This project examines the differential impacts of isolated illiteracy and proximate literacy on various social and economic decisions like child schooling, child labour, fertility, adoption of

scientific methods in agriculture etc. The field work for this project was done in Assam. The work for this project is complete and the report will be ready shortly.

A workshop on 'Quantitative Analysis of North East Indian Economy' was organised in collaboration with the Department of Statistics, Gauhati University. The workshop was held at Gauhati University, Guwahati, during 24 February - 1 March, 2003. The purpose of this 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 related quantitative techniques to analyse them. Twenty six workshop participants were selected from Research Scholars/Faculty members in Economics/Statistics of under-graduate colleges and universities in North-East India, of which seventeen turned up from colleges/universities of Guwahati, Agartala, Karimgunj, Jorhat, Tezpur, Dibrugarh, Kohima, Itanagar and Imphal. The topics of discussion covered in the workshop were Microeconomics, Macroeconomics, Econometric Methods and Applications. Resource persons consisted of members of E.R.U. faculty and Professors of departments of Statistics and Economics of Gauhati University. The workshop turned out to be a success and the responses from the participants were overwhelming.

Under the fourth plan project 'Conference on Models and Methods in Economics', was held during 5-7 March, 2003. The conference was well attended and twenty-two speakers from all over the country participated in the conference.

Economic Analysis Unit

Research Activities

The unit has been 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 the areas of current interest.

Research in Transfer Pricing, an emerging area of work in Finance, is being pursued by the research scholars of the unit.

Linguistic Research Unit

The Linguistic Research Unit continued its programme of research in the areas of Quantitative Linguistics with special emphasis on Sociolinguistics, different aspects of Language policy and planning, Syntax, Text Analysis, Philosophy of Language and Clinical Linguistics.

Research Activities

Methods in Quantitative Linguistics

A review of applied linguistic theories relevant to probabilistic approaches in language research. Problems of categoricity. The greater explanatory power of probabilistic models. Grammatical weight, grammaticality and variation, Probabilistic grammars, contingency table statistics - subcategorization & statistical inference. The multi-dimensional approach to linguistic analyses of sociolinguistic and psycholinguistic phenomenon: Research design and methodology in language attitudinal research.

Syntax

Linguistic algorithm and cognition in Panini and Navyayaya: Non algorithmic approach to language – Bhatrihari, Mimamsaks and Nagesa: In this project, Empty Category Principle (ECP), Deletion and Trace-phenomena as proposed by Noam Chomsky, are reinterpreted on the basis of *Nyaya Vaisesika* category *"abhava"*. This reinterpretation helps to understand the semantico-pragmatic content of language. During 1980's, there was a controversy on the status of deletion-erasure phenomena and it was questioned whether the phrasal category itself is deleted along with the recoverable lexical category. Chomsky (1995) answered in the

negative. The *abhava-theory* is also deployed here to understand such cases of deletion-erasure and recoverability principle in special reference to Bangla sentences. This project is to analyze Bangla Negative sentences in the light of *abhava*.

Clinical Linguistics

(a) Aetological and Diagnostic approaches to Speech Pathological Problems. (b) Habilitation of hearing impaired children The study aims at evaluating Bangla speech sounds for different groups of hearing impaired children. Analytical tests have been carried out which bring to light, the elements which are correctly pronounced and those which suffer deviations from the accepted norms. This was specially oriented for defining the transitions between each component of sound in various patterns of sound sequences --- the focus of the problem in the hearing impaired children. The habilitation process involving the combination of the various speech sounds to produce meaningful utterances has been considered in the final stage of the rehabilitation programme. The suprasegmental aspects have also been utilized by the habilitator throughout the habilitation programme.

Projects Undertaken

Methods in Quantitative Linguistics and Cognitive Science

The research concentrated on the soft constraints inherent in linguistic systems. It attempted to justify that there are such constraints, and that they can be modeled, based on quantitative (Statistical and Algebraic) evidence obtained from linguistic corpora or empirical data. The focus was on models that achieve linguistic explanation, etc. The aim was to develop methods for statistical data analysis and for building probability models of language. A part of the work has been published and the first part of the manual on methodology in QL is under preparation.

Bangla English Interference

Survey and data collection has been carried out from different Bangla medium schools from all the districts of West Bengal with a view to examine the effect of interference of English language in the learning of Bangla in the educational system of West Bengal. The data which contains soiolinguistic as well as psycholinguistic informations have been analysed in detail. The linguistic interference corpus is also analytically studied by deploying various theories like Item-Response theory, etc. The measurement of interference along with the statistical analysis of the sociolinguistic data has been completed. The extent of interference of English (L2) in the realm of Bangla (L1) has been worked out, which may be implemented in future as a part of language policy. Two papers have been published based on this research.

Linguistic Ecology

To underline the causes of linguistic imbalance as well as the linguistic pollution and contradiction, empirical research has been carried out in various linguistic zones. For the linguistic remedy suggested by the project that is planning from below or a decentralized planning (economy and language) data has been collected from various spheres of print, electronic, advertisement media, politico-administrative set up, educational infrastructure, etc. The project has attempted to highlight the implementation of the findings in the realm of education as well as in decentralized politics by relay-network. Some of the work has been published.

North East

Subaltern Linguistics

Work has been carried out on various language movements – Assamese, Boro, Kamtapuri and Santali. Data was collected and analysed on the Kamtapuri language movement in Jalpaiguri, Dhupguri and north Cooch Bihar areas of North Bengal. Work was also carried out in Dhanbad, Jamshedpur (Jharkhand), Purulia, Burdhwan and Birbhum districts of West Bengal on the Santhali language movement from the socio-political

and socio-ethnic perspective. A careful study of the Mizo language movement was also carried out in Aizawl, Chaltlang, Lunglei, Lengpui and Zwarkoat areas in Mizoram. Work on Assamese and Boro was also undertaken in Guwahati and Lower Assam. Reports on all these language movements were submitted to appropriate authority. All the reports on the language movements brought out by the Unit have been proposed for publication by Central Institute of Indian languages, Mysore, under the Ministry of Human Resource Development.

Planning Unit

Research Activities

Members of the Planning Unit at Delhi carried on a wide range of research activities. Some of the areas in which research was undertaken are: (i) Food policy in India with special reference to the efficiency of existing food subsidies, (ii) Theoretical and empirical analysis of the difference in performance levels of private and cooperative plants in the Indian sugar industry, (iii) Theoretical and empirical work on the link between poverty, local governance and deforestation in Uttar Pradesh and Himachal Pradesh, (iv) Poverty measurement, (v)Empirical Testing of the impact of HYV seeds on household welfare, (vi) Analysis of home-ownership patterns across communities in the US and its impact on the provision of local public goods, (vii) Fiscal reforms in India, (viii) Trade and foreign investment policy and their impact on personal distribution of wealth and income, (ix) Political economy, endogenous growth and distribution, (x) Agricultural insurance, (xi) Bankruptcy and debt recovery procedures with special reference to India, (xii) Auctions, (xiii) Strategic voting theory, (xiv) Environmental degradation in India, (xv) Evolution of preferences and cooperation, (xvi) Group heterogenity and public good provision in India, (xvii) Racial income disparities and residential segregation in the US, (xviii) Analysis of the impact of piped water on the health status of children in rural India, (xix) Impact Evaluation, (xx) Factors affecting the efficiency of public good allocation, (xxi) Effects of liberalization on the skill based technical change in Indian Industry, (xxii) Patronage in Public administration : the case of South Korea.

Population Studies Unit

Research Activities

A study on Cross-sectional as well as temporal variation in gender bias among the Work force in Eastern India.

The objective of this study is to find out whether gender discrimination is on the wane in different East Indian States through appropriate demographic, regional analytic and statistical techniques.

Factors associated with labour absorption in various economic activities in urban and rural areas of India.

Non-linear multiple regression techniques are being employed to explain the variation in labour absorption by varying level of different influencing factors such as skill, economic condition, and so on.

Generating Life Tables for the Districts : A Model Approach

Due to non-availability of death statistics by age at the district level, this study attempts to estimate infant, child and adult mortality by considering children ever born from surviving by sex classified by age of mother and widowhood status of male/female spouse by age. The age specific mortality rates by sex are derived by blending two different sets of survivorship probabilities, namely (1) child survivorship probabilities and (2) adult survivorship probabilities with a view to derive abridged life tables by sex generated by Brass Two Parameter Logit Life Table systems.

Study on some standard mathematical modeling on automobiles and environmental pollution in the city of Kolkata

The study tries to accommodate the 'number' syndrome of automobiles which is observed to be increasing at a faster rate in big metropolises of India in recent time, in a kind of standard mathematical

framework which is initially of some exponential type and ultimately converging to a logistic type in the long run. This model is then applied to focus on the environmental pollution in Kolkata, particularly from automobiles which are growing rapidly in recent times.

Fertility Differentials by Ethnicity in Tripura

The population of Tripura is heterogeneous. Two major ethnic groups live in Tripura : Bengalees and the Tribal population. The international migration, especially the influx of Bengali Hindus from East Pakistan was responsible for the differential growth rates among tribal and non-tribals upto 1961. Thus the growth and composition of population in Tripura depend mainly on fertility. Therefore, differential in ethnic fertility is examined in the light of characteristics hypothesis and interaction hypothesis.

To estimate net difference by ethnicity, the technique of MCA has been adopted. Dependent variable for the analysis is children ever born and the independent variables are : education of husband, or education of eligible women, ownership of agricultural land, family income per annum, occupation of eligible women, experience in child mortality, etc. The analysis shows that differentials in marital fertility by ethnicity persists even controlling for socio-economic and demographic variables.

A Multivariate Approach in Finding out the Various Causes of Age Reporting Errors in Indian States.

People misreport their ages in censuses / Surveys because of some known and unknown factors of socio-economic nature either singly or in combination. Present study is engaged with this type of investigation through NFHS data on Indian states in 1992 – 93 and 1998 – 99 periods.

Projects Undertaken

The Success and the Failures of the Indian Population Control Programmes in the North-East : Setting Directions for Future Research

Population control and the associated programmes that have been implemented in the North-East, especially in Assam, Tripura and Meghalaya were reviewed along with various policies that had been formulated and followed for controlling population growth. On the basis of the review and interactions with functionaries, this study suggests some directions for future research and formulates policies for more effective control on the population growth.

Health Care Practices and HIV/AIDS awareness level among sex workers - A Case Study in North 24 Parganas

This study analyses the nature of illness and morbidity patterns of sex workers, their health seeking behaviour and awareness of HIV/AIDS in two clusters of the North 24 parganas. In the first phase, the study tries to develop a data base by canvassing an elaborate questionnaire among the sex workers containing every possible question about their socio-economic and demographic characteristics along with detailed information on their illness and health care practices. Field work has been completed and data processing is going on. The second phase on qualitative study of HIV/AIDS awareness programme is currently in progress.

A Baseline Survey on Reproductive Health of Women Among Urban Poor in Kolkata Metropolitan Area.

The objective of this project is to study the prevalence of Reproductive Tract Infection and Sexually Transmitted Infections (STI) among females; incidence of morbid conditions / complications due to mismanagement of MTP cases and Gynecological morbid Conditions. Data collection is completed. Data processing and analysis are in progess.

Research activities

Short term memory span assessment with successive decrease in stimulus presentation time

Preliminary data collection was completed and analysis is going on to determine the effect of individual differences on the memory span with successive decrease in stimulus presentation time. Findings will be useful in exploring several issues of short-term memorizing capacity and pattern of forgetting.

Organizational health of Rural banks

Data collection from rural banks is over and is in progress from urban banks. Findings will be useful in development of optimized human resource management models to improve quality of working lives of employees of both rural and urban banks.

Self-Construal, Personal Values and Attitude towards Dowry

The study has been conducted on college students of two different cultures 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 difference was observed on different dimensions of personal values, self-construal and attitude towards dowry with respect to gender and culture.

Internally funded Plan Projects

Development of questionnaire for assessment of reading and writing motivation of Boys and Girls of Grades III & IV

Final project report has been submitted findings are important for development of teaching models for reading and writing motivation of students in primary education.

Entrepreneurial Behaviour and Individualism-Collectivism

The objective of the study was to find out the personality characteristics, task motivation and individualist-collectivist orientation of small-scale entrepreneurs. Data have been collected from West Bengal, Karnataka, Gujarat and some North-Eastern states of India. The data so far analyzed reveal that there is positive relationship between success rate and task motivation and individualist orientation of entrepreneurs. Most of the entrepreneurs were found to be first generation entrepreneurs and it indicates that they have a desire to achieve something on their own efforts and be independent.

A study on Socio-Psychological Aspects of Mental Retardation

The project proposes a Socio-Psychological study of moderately and mildly mentally retarded pupils who get themselves enrolled in the normal Primary schools, but cannot cope up with the school curriculum. The study has been conducted in three North-Eastern states, viz., Arunachal Pradesh, Assam & Tripura. Data collection has been completed, data Processing is progressing and the final report is expected soon.

Study of the results of H.S., CBSE and ICSE in West Bengal

The objective of the study is to analyze the results of three important public examinations and compare the standards of three systems by the method of horizontal equating. A stratified multistage sampling scheme has been adopted for the purpose. Six sets of random samples of schools from six districts of West Bengal and one

set from Kolkata have been selected by SRSWOR. Approval and cooperation from the Council of Higher Secondary Examination, West Bengal Board of Secondary Education, Central Board of Secondary Education and Council for the Indian School Certificate Examinations have been ensured. Materials relevant for the project have been collected from the respective Boards. Different schedules for the study have been prepared. Syllabus and Question papers for last ten years have been collected and content of evaluation is being examined for Physics, Mathematics and English.

Sociological Research Unit

Sociological Research Unit has been carrying out over the recent years several internally funded and externally funded 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) decentralisation of planning process, (iii) evaluation of socio-economic impact of literacy movement, (iv) religious and ethnic problems, (v) role of outstanding thinkers and research institutions in social transformation, and (vi) new methodological research for social network analysis by using probabilistic and graph theoretic techniques. These research themes have been empirically taken up by SRU mostly at headquqrters in Kolkata covering West Bengal and partly at Giridih Branch in Jharkhand.

In Giridih, SRU has recently undertaken two new projects : one envisages to explore potential power structure with emphasis on social network in the selected villages of Jharkhand, while the other seeks to examine the responses of the households to macro processes related to decline of mica industry in Giridih town. Now SRU has also been able to take up empirical projects on social transformation in other states such as Tamil Nadu, Kerala and Tripura.

Another distinct trend is the growing academic interaction of SRU with Theoretical Statistics & Mathematics Unit as well as with Economic Research Unit, Psychology Research Unit, Biochemistry Unit, Agricultural Science Unit, and Population Studies Unit. This interaction was reflected in several inter-disciplinary project reports completed in the recent years. Two examples may be cited : (i) "Statistical analysis of academic performance of primary school students" and (ii) "an exploratory statistical analysis of the effect of demographic risk factors on uterine cervical cancer".

Internally Funded Projects

Economic Reform and Rural Development : A Study of Agricultural Labour in Eastern India

A striking feature of nationwide data on employment in India is the decline in growth rate in employment in rural India in the 1990s. It has been noted that data from the 55th Round of the NSS show that the period 1993-94 to 1999-2000 saw "the lowest rate of growth of employment in post-Independence history". The period was also marked by a sharp decline in the employment elasticity of rural output growth and by a steady process of casualisation on the rural labour force.

The States of eastern India constitute an important area of agricultural change in our country. An analysis of change in agricultural employment and rural development requires reliable primary data as well as data from secondary sources.

The project attempts to study the socio-economic characteristics of agricultural worker households, based on village-level samples in different States. A model questionnaire has been prepared to gather data on the general characteristics, employment, wages, earnings, asset-holdings and indebtedness of worker-households as well as on their access to State-run development and welfare scheme.

The Burden of Child Labour : Assessing the Impact of work on Child Nutrition and Development.

There is quite a large body of research on the incidence of child labour, on the nature of activities children participate in and on their earnings. There is also a literature, though less extensive, on "hazards" at

work. However, there is very little known on the impact of work at an early age on the physical development of a child.

This project makes a start in this direction by collecting information on the impact of work on children's physical development (based on anthropometric and other measures).

The project intends to undertake surveys of working children in different locations known to have concentrations of children working in non-agricultural activities. The survey will cover children of different ages and children engaged in different activities. Data will be collected from different locations including West Bengal, Bihar/Jharkhand. Tamil Nadu, Gujarat and Uttar Pradesh. Two of the locations will be Giridih in Jharkand where empirical study will be undertaken on children in the mica industry and Bhavnagar, an area on which publications have already come out.

About 250 children will be surveyed : the exact size of different surveys will be decided after preliminary investigations.

Nationalism, Modernity and the Indian Statistical Institute

This is a project to write a history of the Indian Statistical Institute with a focus on its relationship with the life of the Indian nation for the periods before and after India's independence. Although the history will be written from official and historical records of the Institute, government sources and private papers, it will aim at an objective, not a biographic, account by situating it in a broader arena.

The work of the Indian Statistical Institute was begun in pre-Independent India when nationalism and modernity were very much in discussion. Western education and ideas of humanism acted as a catalyst in India's transition to modernity. An important beginning was made towards 'constructive swadesi' or working for the development of nationhood outside the political forces. The pioneering work of the Indian Statistical Institute became intimately linked to this paradigm through the channels of education, research and training. The Institute was one of its kind to take off in that direction from the early years of the twentieth century. It developed itself into a wide-ranging centre of learning and action for high levels of scientific specialization with the stated social purpose of bringing science, reason and humanism to Indian life. Schooled in the ideas of Rammohan Roy and Rabindranath Tagore, the founder of the Institute went in for co-operation with the contemporary world and not isolation from it. This was a major response in India's historiography of modernity.

Research for this project hopes to demonstrate how the work of the Institute became an important link with nation-building in pre-Independent India and with Indian Planning in the post-Independence era. There will be scope for a critical assessment of its successes and failures within the discourse on Indian Planning and its bearing on national development.

Patterns of social relations : an exploratory social network analysis in two villages in Jharkhand.

The objective is to study the potential power structure with emphasis on social linkage in two villages of Jharkhand in order to find out whether exposure to market influences has any effect on the structure of domination in a village. Data collection, data entry and analysis have been completed. Report writing is going on.

Gender and Labour : a study of mica industries of Giridih

The purpose is to identify variations and changes in women's employment through different forms of production, retrenchment due to fall in export of mica products and the impact this has on women's bargaining power within the household. An interim report has already been submitted on linkage between informal sector in mica industry and conditions of women. Further analysis on consumption pattern, pooling of income and occupational disease is being carried out.

Agrarian change in Southern Tamil Nadu 1977-2000

The project involves writing papers and a book based on statistical data gathered in one village and region of southern Tamil Nadu. Census type surveys of households in the village were conducted in 1977 and 1999; other quantitative data were collected in the intervening years. A few studies of individual agriculture workers and of new forms of employment in the village will be conducted. The project aims to put together a composite picture of agrarian relations and the socio-economic characteristics of hired rural workers in a changing agrarian system. The study will use primary data to track a series of economic indicators.

The study of socio-economic impact of Total Literacy Campaign in a district of Tripura

The project envisages to study the socio-economic impact of Total Literacy Campaign (TLC) in West Tripura District of Tripura and compare it with the finding of a similar empirical study earlier undertaken by ISI in Birbhum district of West Bengal. One of the objectives would be to locate the variations, if any, in the process of socio-economic impact of TLC and find out the causal factors for such variations. The sample survey was carried out, covering the district of West Tripura and encompassing both the urban and rural areas. The data collection is over and the data processing is in progress.

Externally funded Projects

Empirical study on the labour-related problems of tea gardens in West Bengal (funded by the Labour Department, Government of West Bengal)

The objective of the project is to prepare a comprehensive report, on the basis of field data already being collected from the tea gardens of North Bengal (consisting of the Dooars in Jalpaiguri district, the plantations in the hill region of Darjeeling district and the Terai comprising the plains of the same district), suggesting a modality for a long-term optimum solution of the problem of casual workers in the tea plantation industry in West Bengal. The report would take into account land-labour ratio, additional new plantation, production, productivity, financial ability of the individual tea gardens, present employment pattern of permanent and temporary workers and other relevant factors. The project is likely to be completed by July, 2003.

Study on Status of Women in West Bengal

The project seeks to complete, using sample survey of households and in-depth case studies, a comprehensive report on the status of women in Birbhum district of West Bengal. This will be a model study that can be replicated subsequently in other districts of West Bengal. The project is expected to build up a reliable data base on major aspects of the status of women, covering demographic and health characteristics, economic participation, literacy, exposure to media, political perception and participation, and socio-cultural (including legal) awareness and attitudes. Using the recall methods and utilising the available official records, as and where possible, the recent changes in the status of women will also be evaluated against the earlier situations, like the position obtaining in the 1970s. The project is likely to be completed by November 2003.

State Development Report

This project is funded by the Planning Commission, New Delhi. It involves preparing a 'Report on Agriculture in West Bengal : Current Trends and Directions for Future Growth'. This will be a chapter in the proposed State Development Report for West Bengal. The Report attempts to take stock of experiences of West Bengal in the path of development with respect to agriculture; to describe how West Bengal agriculture has fared; to describe some of the problems that have emerged; to refer to recent policy statements that have outlined future perspectives for agriculture; to discuss means by which these can be implemented; and to present a set of maps on rural West Bengal.

Statistical Quality Control and Operations Research Division

The Division comprises of SQC-OR (T&P) Unit in the main campus at Baranagar and nine other SQC & OR Units located at Bangalore, Baroda, Chennai, Coimbatore, Delhi, Hyderabad, Kolkata, Mumbai and Pune. A central office located at the main campus at Baranagar, co-ordinates the various activities of the Division. The central SQC office becomes the office of the elected Head of the Division.

One of the primary responsibilities of the Division is to conduct the M.Tech (QROR) course at Kolkata and Part-Time Certificate courses in SQC at Bangalore and Hyderabad. Faculty members of the Division are engaged in teaching and training in academic courses of B.Stat (Hons.), B.Math (Hons.), M.Stat, M.Tech (QROR) and courses conducted by other academic bodies.

The faculty members of the Division have been engaged in carrying out research work as well as supervising research scholars for their Ph.D. One research Scholar has successfully completed his Ph.D and one of the faculty member has submitted his thesis for Ph.D.

The faculty members are also engaged in imparting on-the-job training for M.Stat and M.Tech (QROR) students and guiding their projects and dissertations. A large number of students of various courses like MCA/MBA of other academic bodies are benefited by the guidance provided by the Divisional faculty members.

Training and consultancy is one of the major areas of the faculty in the Division. The industries benefited by these activities are many : Reliance, L&T, Infosys, Novell, Godrej Saralee, to name a few. The division's faculty have actively participated in collaborative projects with Applied Statistics Division.

The division also conducted a Winter School and a number of Seminars and Symposia. Faculty members of the Division attended a number of Conferences / Seminars and delivered invited talks/lectures. The Division continued the Quality Mission Project for the tenth year since inception. The details of these activities are given below..

Areas of Research Activities:

Software Reliability, Consecutive K-out-of-n : F System, Reliability of Shared Loan Parallel System, Life Distribution, Linear Complementarity Problem (LCP), Semi Definite Linear Complementarity Problem (SDLCP), Noncooperative Games, Stochastic Games, Cooperative Games, Modeling for Defects in Software Development Process, Modeling of the Measurement Process, Development of Univariate and Multivariate Process Capability Indices, Optimization Procedure for Maximal Matching, Multi Objective Programming, Six Sigma, Generalized Inverse, Applied Regression Analysis and Regression Diagnostics, Bioequivalence, Properties of Linear Transformation – Lyapunov, Stein and Double Sided Multiplication.

SQC & OR Unit, Bangalore

Research Activities

Research has continued in areas like Global Univalence and Jacobian Conjecture and some interconnections between direct monotonics, GUS and P-properties in semi-definite linear complementarity problems.

Other Academic Programmes:

Six months part time certificate course has been conducted for

January – June, 2002 Session
July – December, 2002 Session

Training Programmes:

Sl. No.	*Title of the Program*	*Duration*	*Organization*
1	Black Belt Training Program	3 days	Grindwell Norton Ltd., Bangalore
2	"	2 days	"
3	"	2 days	"
4	"	1 day	"
5	Six Sigma Black Belt Training	4 days	Praxair India Ltd., Bangalore
6	"	6 days	Motor Industries Co. Ltd., Bangalore
7	"	5 days	"
8	"	4 days	"
9	"	3 days	L & T, Mysore
10	"	3 days	"
11	"	2 days	"
12	"	2 days	"
13	"	3 days	KEC, Bangalore
14	"	3 days	KEC, Hubli
15	Six Sigma Champions' Program	2 days	Motor Industries Co. Ltd., Bangalore
16	Six Sigma Green Belt Program	3 days	Praxair India Ltd., Bangalore
17	"	3 days	"
18	"	3 days	"
19	Statistical Tools of Six Sigma	3 days	Praxair India Ltd., Haldia
20	Six Sigma Overview	1 day	Lincoln Helios, Bangalore
21	SPC Training	2 days	Sasken Systems, Bangalore
22	Simple Tools of QC and Team Oriented Problem Solving	2 days	Otto Bilz, Bangalore
23	PFMEA	1 day	IFB Industries, Bangalore
24	Measurement Systems Analysis	1 day	"
25	SPC	3 days	Vikrant Tyres Ltd., Mysore
26	PPAP	1 day	IFB Industries, Bangalore
27	APQP	1 day	"
28	Top Management Briefing on ISO TS 16949 : 2002	1 day	Vikrant Tyres Ltd., Mysore
29	Top Management Briefing on Process approach	1 day	IFB, Goa

30	ISO 9001:2000	1 day	"
31	DOE	3 days	Vikrant Tyres Ltd., Mysore
32	TAC Tools	1 day	IFB Industries, Bangalore
33	Process Approach	1 day	Vikrant Tyres Ltd., Mysore
34	Acceptance Sampling	2 days	i2 Technology, Bangalore
35	Cost of Poor Quality	1 day	IFB, Goa
36	ISO TS 16949 : 2002	4 days	Vikrant Tyres Ltd., Mysore
37	Measurement System Analysis	1 day	"
38	Process Approach	3 x 2 days	J K Industries (New Delhi, Gwalior, Udaipur)
39	ISO TS 16949 : 2002	3 x 2 days	"
40	IQA on ISO 9001 : 2000	3 days	IFB, Goa
41	Process Approach	1 day	IFB, ASSL
42	Application of SPC in Software Engineering	1 day	Sasken Systems, Bangalore
43	Six Sigma Champion program	1 day	Grasim Industries Ltd., Haribar
44	Six Sigma	20 days	Motor Industries Co. Ltd., Bangalore
45	"	20 days	AT & S, Nanjangud
46	Measurement System Analysis	2 days	"
47	ISO - 9001:2000 Awareness program for Top Management	2 days	Bharat Builders, Bangalore
48	"	3 days	Mormugao Port Trust, Goa
49	Internal Quality Auditors training	3 days	Bharat Builders, Bangalore

SQC & OR Unit, Baroda

Research Activities

Optimum sampling interval for control of defective items in a hot rolling mill has been developed. An economic model for the same problem is developed in line with the method suggested by Taguchi. An expression for the expected loss per product as a function of the sampling interval is derived. Practical issues like estimation of various cost components are addressed through sensitivity analysis.

Some inequalities for systems having multiple failures/shocks having log-concave and concave distribution are developed.

An algorithm was developed for computing multivariate normal probabilities to facilitate cost - effective managerial decision making.

Optimum packing machine parameters were found out in order to minimize the variation in packed bag weights in a Urea manufacturing plant.

Other Academic Programmes :

Correspondence course on Statistical Process Control has been continued with 35 Participants. This programme has become quite popular in the industries around.

Externally Funded Projects

Using Taguchi methods to optimize the raw material mix in a dye at Devarson's Industries, Ahmedabad.

The objective of the project was to arrive at an optimum combination of proportions of raw materials in order to maximize the yield and minimize the quality loss. A two-stage experimentation was conducted using an L_{27} orthogonal array in the first phase and a 2^3 full factorial in the second phase to obtain the best combination.

Reduction of electricity generation loss by adjusting generation level to predicted system demand at Ahmedabad Electricity Corporation.

Existing generation capacity of Ahmedabad Electricity Corporation is less than the demand in the peak period but is more than that in the lean periods. Accordingly generation level is increased to maximum capacity during peak demand period and lowered to match the system demand in other periods. However with the existing generation management system the company was suffering from substantial generation loss due to 'early slow down' and 'late pick up' of generation level. In order to reduce such generation loss, a control scheme has been developed based on prediction of system demand (time series forecasting) and adjustment of generation level (with a transfer function model) to the predicted level of demand.

Two more projects on Implementation of ISO 9001 : 2000 in ONGC, Mehsana and Implementation of ISO 9001:2000 in 45 field and 8 branch offices of AC Nielsen ORG-MARG Pvt. Ltd., Baroda have been taken up.

Training Programmes :

Title	*Date*	*Organization*
Awareness of Six-Sigma Quality	3-4 April, 2002	Tata Chemicals Ltd., Mithapur
Failure Mode and Effects Analysis	28 August 2002	Phillips Carbon Black Ltd., Palej
A re-look at ISO-9001:2000.	18 September 2002	Kalpataru Power Transmission Ltd Gandhinagar
Statistical techniques for Quality	19-20 September 2002	Vimal Microns Ltd., Mehsana
Statistical techniques for ISO 9001 and QS 9000	28 September 2002	Ishiwana Consultants
SQC	16 & 18 January 2003	Ahmedabad Electricity Ltd.

SQC & OR Unit, Chennai

Research Activities

Semidefinite Linear Complementarity Problems

Equivalence of P- and Q- property for multiplication transformation M_A is established, where A is symmetric; Sufficient conditions are derived for M_A to have strong monotone property; When A is normal, equivalence of P- and P_2- property is proved.

Process Capability Indices

Capability evaluation of non-normal process; joint distribution of estimator for (C_p, C_{pk}); joint confidence interval for (C_p, C_{pk}).

Stochastic Games

Generalization of Nash equilibrium theorem for 2 players with SER-SIT (separable rewards and state independent transitions) assumptions. Formulation of such a game as a VLCP.

Externally Funded Projects

Development of Optimal Strategy in Copper Ore Trading with Overseas Suppliers to Minimize Loss, Sterlite Industries (India) Ltd.

Copper ore is procured by Sterlite Industries (India) Ltd. from various suppliers (traders) in the international market for manufacturing copper anodes. The payment related to this ore is based on the percentage content of copper, silver and gold, which are obtained from laboratory analysis of the composite sample prepared from each consignment. Such analyses are carried out by both the parties. However, results of analyses reported by traders are most often substantially higher than those of Sterlite, indicating a large perceived loss to the company. This study makes an assessment on the extent of financial loss, and develops an optimal strategy to minimize the same under different circumstances, through statistical modeling and simulation.

On Selective Assembly of Lenses, General Optics (Asia) Ltd.

Two lenses of different kinds are assembled linearly to make a module of an optical system. Random assembly produces very high level (about 60%) of rejection/rework due to non-compatibility (in the sense of statistical toleraneing) of module tolerance with individual lens tolerances. Existing procedure of selective assembly could give rise to only 60% acceptable assembly on the average, leading to complicated system of management for the left-over lenses. An optimization scheme is introduced for selective assembly in order to achieve maximal matching having minimum squared deviation from the nominal target value of the module. The acceptance level is now increased to nearly 100%.

Determination of Optimal Quantity of Bought out Green Tea Leaf, Parry Agro Industries Ltd.

The company has two factories that make black tea from green tea leaf. The total quantity of green leaf obtained from its estate gardens is less than the total capacity of the factories. The company enters into annual agreement with private parties for supply of all green leaf from their respective earmarked gardens. On any day, excess leaf (=Total Estate leaf + Total Bought-out leaf – Total Capacity of the factories), if there is any, is required to be sold out at much lower price than the purchase price of bought-out leaf. On the other hand, there are days with under utilization of factories. This study aims at determination of the optimal quantity of bought-out leaf that maximizes the net profit by taking into account the differential output quality (and hence profit margin) of the factories.

Training Programmes:

Title	Period (No of days)	Company
Statistical Process Control	2	Chemplast Sanmar Ltd.
Statistical Methods	3	Rane (Madras) Ltd.
Statistical Process Control	2	Jaihind Engineering
Statistical Methods	3	General Optics (Asia) Ltd.
Sampling Techniques	3	Sterlite Industries Ltd.
Statistical Process Control	2	Chemplast Sanmar Ltd.
Statistical Process Control & Design of Experiments	3	General Optics (Asia) Ltd

SQC & OR Unit, Coimbatore

Externally Funded Projects

ISO 9001 certification for DEE CEE Exports

The company was awarded ISO 9001 certification, which includes design and development.

ISO 9001: 2000 certification for N.C. John & Co

Under the UNIDO cluster programme, a number of companies in and around Tirupur were identified and training and expert help was provided to the companies for implementation of the quality management system. One such organisation got the coveted certificate for ISO 9001 : 2000.

Several other projects regarding SPC implementation, and product and process improvement have been taken up by the faculty members of the unit.

SQC & OR Unit, Delhi

Research Activities :

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

Externally funded Projects

Statistical Analysis of Proficiency Testing Programme on Egg Powder Testing at National Accreditation Board for Testing and Calibration Laboratories (DST)

In all 73 laboratories from 27 different countries participated in this programme. Statistical analysis was carried out to assess the performance of the participating laboratories on the various characteristics of egg powder by SQC & OR Unit, Indian Statistical Institute, Delhi Centre. This project was sponsored by APLAC, National Accreditation Board for Testing and Calibration Laboratories.

Improving heat rate and auxiliary power consumption in NTPC

Heat rate and auxiliary power consumption are the two important indices determining the economics of any power plant. Hardly any work has been done in the use of statistical methodology in these areas. This 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. This project was sponsored by NTPC.

Two more projects on Physical Verification of Food grain in FCI Godowns at Food Corporation of India and Development of Genetic algorithm for path optimization in PCB manufacturing at R Systems International Limited, Noida were completed.

Training Programmes

Title of the programme	*Date*	*Organisation*
Six-Sigma Black Belt training Programme	10-11 April 2002	Samtel Group of Industries
Statistical Process control	15-16 April 2002	Eicher motors limited, Pitampura

Statistical Techniques and Design of Experiments	23-24 May 2002	Escorts JCB Ltd.,
Statistical Techniques for executives	5 days, June-July, 2002	Moser Baer, Greater Noida, U.P.
Awareness training programme on Six Sigma (quality mission project	12 July 2002	National Hydroelectric Power corporation Ltd., Faridabad
Tranning programme on Reliability methods	7-9 August 2002	Eicher Motors Ltd., Pithampura
Training Programme on Reliability Techniques	19-23 Aug, 2002	Power Grid Corporation of India Ltd., New Delhi
Training programme on SQC Methods	10-11 Sept, 2002	BPL Devices Limited
Training Programme on Design of Experiment	25-27 Sept, 2002	Eicher motors limited
Training programme on Six Sigma	27 Sept. 2002	Rites
Statistical Thinking	24-27 Sept, 2002	Samtel
Sampling Techniques	29-30 Nov, 2002	RITES
Forecasting	5-7 Dece, 2002	Eicher Motor
Tranning programme on Statistical Methods for Proficiency Testing	15 - 18 Jan, 2003	SQC & OR Unit ,Delhi

SQC & OR Unit, Hyderabad

Research Activities

The research activities carried out by the faculty members are : (i) development of suitable univariate and multivariate Statistical process capability indices and their comparison with existing ones, (ii)Identifying influential observations in connection with univariate and multivariate process capability indices, (iii) Semi-definite Linear Complementarity Problems, Applied regression analysis, with special reference to regression diagnostics, (iv) Development of suitable testing methods for equality of efficacy of a new drug with a standard drug. (Bio equivalence), (v) In depth study of Six Sigma Methodology and its modification for adoption in Indian industry, (vi) Statistical applications for Benchmarking of Cigarettes, (vii) Determining the effect of Tobacco moisture, environmental conditions and machine conditions on the quality characteristics of cigarettes.

Other Academic activities:

Teaching :

a) Part-time Certificate Course in SQC (February-July 2002) : 29th Batch. Students admitted : 27
b) Part-time Certificate Course in SQC (February-July 2003) : 30th Batch. Students admitted : 21.
c) Faculty of the Hyderabad Unit also took classes at the University of Hyderabad for M.Sc Statistics students of III semester and IV semester. The courses offered were Regression Analysis and Multivariate Analysis.

Externally Funded Projects :

Upgradation of QMS to ISO 9000 : 2000. Process Improvement and Six Sigma Implementations at M/s. Cadsys (India) Ltd.

Existing Quality System has been upgraded to meet the requirements of ISO 9000 : 2000. In the process a number of manufacturing and other processes were improved from the existing level. The company was then introduced to the concept of Six Sigma and how to measure various processes in the sigma scale.

Estimation of electricity consumption by agricultural consumers in Andhra Pradesh

The supply of electricity to electricity consumers in Andhra Pradesh is managed by distribution companies (DISCOMs) which are regulated by M/s Andhra Pradesh Electricity Regulatory Commission (APERC). The agricultural consumers in the state are not metered but are charged on the basis of the capacity of the pump sets used by them. As a result, the quantity of power consumed by the agricultural consumers is not known. However, for the purpose of the regulation, an estimate of this quantity is required. Consequently at the directive of APERC, the DISCOMs conducted a survey to estimate the power consumption of agricultural consumers in the state and submitted the data to APERC. Using the survey data the DISCOMs were directed to estimate the electricity consumption by agricultural consumers under their jurisdiction. In this connection APERC has raised certain queries about the method of estimation and addressed them to the Indian Statistical Institute (ISI) which was also entrusted the task of estimating the *consumption* using the survey data.

This project involved dealing with huge volumes of data and a number of statistical problems that arose from the deficiencies in the survey data collected. This projected was completed successfully and the report was submitted to APERC. An interesting observation was that the power consumption exhibited Weibull distribution pattern in almost all the cases.

Product/Process improvement using Six Sigma methodology at M/s. Nuclear Fuel Complex

Faculty members of the unit helped in carrying out studies aimed at improving various products/processes at various stages.

Modelling of Tobacco yield at ITC-ILTD.

A model was developed for Tobacco yield at ITC-ILTD.

A Multicommodity Network Flow problem in Cement Industry

Latest trend in business optimization is to apply strategies such as Supply Chain Management and Logistics Optimization for business excellence. Most of the industrial and service sector organizations are going for computerization of their operations. Automated decision support systems are becoming essential for quick and efficient solutions to the complex decision making problems for effective planning and implementation. This project is about one such application. M/s. India Cements Limited, a leading South-Indian cement manufacturing company, has a number of production plants situated at various locations in Andhra Pradesh and Tamil Nadu. They produce about 100 brands of cements and supply them to about 12000 stockists spread across the four southern states, Orissa, Maharastra and Goa every month. The movement of material takes place either directly from the plants or through their depots. The company's production plants, depots and their corporate office are all connected through an intranet and most of their routine business transactions are computerized. The objective of this project is to develop web based software with three components, namely:

i) Optimal plant loading and dispatch plan (OPLDP),
ii) Logistics and
iii) Management information systems (MIS).

The main function of OPLDP components is, given the requirements of various stockists (these are the monthly forecasts made by the marketing department) brand-wise, determine the optimal way of loading the plants with various brands and then distributing the same to various stockists so that the overall *contribution* is maximized. The function of the logistics component is to determine the optimal distribution plan and raise invoices based on the actual orders and the availability of products at various plants and depots. The function of the MIS component is to maintain the historical and legacy data and assist the management in periodical reviews of their decision making process.

The main stem of this project is the OPLDP component. This problem falls into the category of multicommodity network flow problem with additional constraints. The size of the problem – prohibitively large – called for special size reduction techniques for efficient and quick solutions. This project has provided a very rich experience in handling large scale optimization problems in practice in terms of dealing with the decision makers, understanding the problem, formulating it, resolving a number of practical difficulties encountered, developing an efficient software solution, leading the software professional in developing the software and finally convincing the decision makers about the huge benefits that may be realized with the help of the decision support system through demonstration using past data. The software was developed and integrated with ICL's intra-network system.

An Application of Cutting Stock Problem at Pressto Forms (P) Ltd

M/s Mahindra & Mahindra Limited subcontracts a number of sheet metal components to its vendors. As part of its ongoing continuous quality improvement and cost reduction programme, the company deputes its executives exclusively to audit and provide support to their vendors on quality assurance and productivity improvement activities. This study was taken up at M/s Pressto Forms (P) Limited, a vendor of the company, to bring about savings through material optimization by adopting well established Operations Research techniques. This study mainly focuses on developing an approach to work out optimal procurement and production plans subject to the production constraints, and to convert the approach into a software solution that will act as a decision support system. It is demonstrated, through this study, that adopting scientific approach to management decisions and manufacturing operations can result in substantial benefits.

Training Programmes

Title of the Programme	*Date*	*Organization*
Statistical Techniques for Process Improvement	April-May 2002 (2 programmes)	M/s. Muclear Fuel Comples.
Statistical Process Control	22-24 May, 2002	M/s. Hyderabad Industries Ltd.
ISO 9000:2000 awareness programme	25 May 2002	ARSIN Systems Pvt. Ltd.
ISO 9000:2000 awareness programme	6 July 2002	M/s. OSI Pvt. Ltd., Trimulgherry, Hyderabad.
Applied Mathematics and Statistics for students of certificate course in Bio-informatics	August'02-March'03	M/s. GVK Bio, Hyderabad
Half-a-day awareness programme on Six Sigma	May, 2002	M/s. Infotech Enterprises
A talk on Sampling Schemes/ISO 9000 : 2000	9 April 2002	M/s. Assam Carbons Ltd.
SPC programme	23-24 May, 2002	M/s. Hyderabad Industries Ltd.
Delivered guest lectures	20-22 May, 2002	M/s. Centre for Electronics and Test Engineering on SPC
Understanding ISO 9000 : 2000 programme	4-5 April, 2002	Conducted at ISI campus, Hyderabad under Quality Mission Project
Statistics in Management to students of post graduate programmes	Series of 25 lectures	Agricultural Business Management of MANAGE, Hyderabad
Simple Problem Solving Tools	Two-day programme	M/s. Voltas Ltd., Hyderabad.
Optimization Techniques for process improvement	20 December 2002	M/s. Mahindra & Mahindra Ltd., Zaheerabad
Training programme on "Statistical Techniques for process improvement in ITES industries"	September, 2002 – February, 2003	M/s. Cadsys (India) Ltd., Hyderabad
Six Sigma Black Belt Training Programme	June-October, 2002 (In five phases)	General Training Programme

SQC & OR Unit, Kolkata

Research Activities

Properties of some classes of matrices in Linear Complementarity Problem and Matrix Games have been worked out. Statistical Process Control was used for Controlling Weight of Packet Biscuits. Some good process control schemes were developed for production in weight variation of capsules.

Other Academic Activities :

One course on Statistical Methods and applications was taken for B.Tech. and M.Tech. standards at College of Textile Technology, Serampore.

Externally Funded Projects

Upgradation of Quality Management system in line with ISO 9001 : 2000 at Coats of India, Calcutta.

Processes have been studied and the existing quality management system has been modified as per the requirements of ISO 9001 : 2000 quality management system standard.

Implementation of ISO 9001 : 2000 at Saraswati Press Limited, Kolkata.

Existing system was fine tuned and necessary training provided for the company to evolve a quality management system in line with the requirements of ISO 9001 : 2000 quality management system standard.

Implementation of ISO 9001 : 2000 at Balmer Lawrie Project Division , Kolkata

Various activities of the project division were studied and a suitable quality management system was developed. The Division has been certified ISO 9001:2000.

Development of an Effort Validation Tool at Novell, Bangalore

Novell Software Development, Bangalore, develops networking products, which are used globally. One major issue in the software development process is to estimate the effort required based on which a project plan is prepared. The project managers used to estimate the effort using the WBS (Work Breakdown Structure) method, where elementary activities are listed and their efforts are estimated on basis of judgment. The major problems with this approach were, (i) there was no way to calibrate the estimate (i.e., the project manager did not know whether the estimate is overly optimistic and requires an upward correction or overly pessimistic), (ii) there were no scientific guidelines for task definition, and (iii) there were no control systems to understand whether a particular task has taken too much or too little time requiring specific action.

In order to take care of these issues, the project characteristics were studied on a phase wise basis and classes of projects were identified. Risk factors were also identified and important ones segregated.

The typical effort required was found for each class of projects Software was developed to capture the efforts on an ongoing basis and update these values. A model was then developed to compare the assessed risk and actual effort to serve as a basis for validation.

The model compares the estimated effort with the typical value (in fact with the distribution of effort for the class of projects) to identify whether the estimated value is on the higher side or not. At the same time the risk is quantified to find whether it is in the optimistic or pessimistic side. These two are presented graphically to identify mismatch, if any, leading to identification of calibration requirement. The tool thus helps the project managers to determine up front whether the estimated effort needs to be changed and, if yes, in which direction.

Apart from these, task guidelines were developed by identifying tasks with large variability (between actual and estimated effort) and control limits were set for routine control. Software was developed to upload the routine control. Software was also developed to upload the routine effort data for usage to facilitate implementation.

The model was tried on an experimental basis and was very successful. As present full scale implementation is being carried out.

Customer Feedback Survey at Coal India Limited

An all-India assignment was taken up to assess the perception of non-core sector consumers in regard to CIL as supplier and their opinion about a proposed change in the system of sale of coal. The ISI team provided inputs for framing the survey design, preparation of questionnaire, sampling scheme and modus operandi of the survey with active participation of the client organization. To start with, the countrywide database of current customers was collected from CIL. Draft form of the questionnaire was validated by sending the same to a small sample of consumers, randomly selected from three high consumption and easily accessible states, namely Bengal, Bihar & UP. Based on the outcome of the analysis of this initial feedback data, final sampling frame was selected. State-wise sampling units were chosen using PPS algorithm and within a state samples were chosen randomly. Moreover, number of units was so selected that sampling error of the estimate of proportions does not exceed 0.04. Broad areas that was covered in the survey were :

Consumers feedback regarding quality and quantity,

Perception of direct consumers and consumers taking the service of middleman,

Preference towards proposed systems (namely Contract, Annual Demand Registration and Quarterly Booking) of procurement, and

Likeliness to use e-com facility.

Data thus obtained were analysed using log-linear analysis to understand the structural relationship among the different attributes and corresponding responses.

Results of the analysis are as follows

- ✓ Estimated percentage of consumers who are more or less satisfied with respect to quality and quantity is 43.6% and 51.2% respectively. The level of satisfaction with respect to quality is marginally higher for consumers taking coal directly from CIL.
- ✓ Regarding service quality, middleman scores are marginally higher than CIL's. Interestingly, the overall rating of CIL by High Consumption (annual consumption of > 25000 MT) is higher than that of Low Consumption group.
- ✓ About 65% of the consumers preferred Contract. Almost 60% of the rest preferred Annual Demand registration and rest opted for Quarterly Booking. Most of the consumers preferring Contract opted for the short period of agreement (1 year).
- ✓ About 77% of the consumers favoured the use of e-com facility.

Externally Funded Projects :

Forecasting of sales

Clients are interested in the seasonal fluctuation of sales figure of their product and also the effect of anti-dumping duty levied by the Govt. of India. Sales data were collected for 10 years and analysed. It was found that the sales are dependent on seasons and it helped the organisation to plan manufacturing accordingly.

Implementation of Six Sigma at Reliance Industries Limited

M/s Reliance Industries Ltd. approached the Unit for assistance in implementing SIX SIGMA philosophy at their manufacturing location. During the first year, all the plants were identified. Sixteen projects have been successfully completed and several Champions, Black belts and Green belts were trained to carry out the projects smoothly.

Implementation of Six Sigma at Larsen & Toubro Limited, Electrical & Electronic Business Group.

M/s Larsen & Toubro Limited, Electrical Business Group approached the Unit for assistance in implementing SIX SIGMA philosophy at all their manufacturing locations. During the first year, all the plants were identified. Seventeen projects have been successfully completed and several Champions, Black belts and Green belts were trained to carry out the projects smoothly.

Productivity Improvement in Glass Manufacturing Industry

Pack to melt ratio of a glass manufacturing industrial unitt was 82%. The manufacturing process was analyzed and various process parameters were optimized. This resulted in improvement of the ratio to 86%.

Besides the above externally funded projects, the unit has taken up several other externally funded projects like SIX Sigma implementation at Huber Chemicals and HDFC Limited and manufacturing process improvement at Classic Stripes Ltd. and Coats of India Ltd.

Training Programmes :

Sl. No.	*Title of the Programme*	*Dates*	*Organisation*
1.	Black Belt, Control Phase	April 2002	Larsen & Toubro Ltd.
2.	Black Belt, Improve Phase	April 2002	Reliance Ind. Ltd
3	Programme on DoE	May 23, 2002 June 28, 2002, July 8-9, 2002	Mahindra & Mahindra Ltd.
4.	Awareness Programme on ISO 9000 : 2000	June 18, 2002	Godrej & Boyce Mfg. Co. Ltd.
5.	Black Belt, Control Phase	July, 2002	Reliance Ind. Ltd.
6.	One day Awareness Programme on Six Sigma	July, 2002	Lloyd's Register of Shipping
7.	Six Sigma-Green Belt	8,9 August, 2002	Reliance Ind. Ltd.
8.	Six Sigma – Executive Brief	12-13 Aug, 2002 & 5-7 Sept, 2002	Huber Chemicals Limited
9.	1-day workshop in DoE	17, 24 Aug, 2002	Mahindra & Mahindra
10.	Six Sigma - Green Belt	23-24 Sept, 2002 28-29 Oct, 2002 18-19 Nov, 2002 9-10 Dec, 2002 3-4 Feb, 2003	Reliance Ind. Ltd.
11.	Six Sigma Black Belt (Define)	1-5 Oct, '02	Larsen & Toubro Ltd.
12.	Six Sigma – Black Belt (Analyse)	14-16 Nov, 2002 16-18 Dece,2002	Larsen & Toubro Ltd.
13.	Statistical Process Control	21-22 Oct,2002	L&T, Nasik Glass Plant
14.	Six Sigma – Black Belt (Define)	23-26 Oct,2002	Reliance Ind. Ltd.
15.	Six Sigma – Green Belt	21-23 Nov,2002	Huber Chemicals Ltd.

		21-23 Jan, 2003 30 Jan to 1 Feb, 2003	
16.	Statistical Process Control	17-19 Dec,2002	Gabriel Industries Ltd.
17.	Six Sigma – Black Belt (DFSS)	21-22 Dec,2002	Larsen & Toubro Ltd.
18.	Six Sigma-Analyse (3rd cycle)	13-16 Jan, 2003	Reliance Ind. Ltd.
19.	Six Sigma-Improve	16-18 Jan, 2003	Larsen & Toubro Ltd.
20.	Six Sigma – Control Phase	21-22 Feb, 2003	Larsen & Toubro Ltd.
21.	Six Sigma – Black Belt	9-10 Mar,2003	HDFC Ltd.
22.	Six Sigma – Black Belt (3rd wave)	24-26 Mar,2003	Reliance Industries Ltd
23.	Six Sigma – Control Phase	24-25 Mar,2003	Reliance Industries Ltd.

Apart from the above listed training programmes three general training programmes with two days' duration were conducted on "Six sigma for business benefits".

SQC & OR Unit, Pune

Externally Funded projects :

Six Sigma Implementation at Reliance Industries Ltd., Hazira,
Six Sigma Implementation at HEG Ltd., Bhopal,
Implementing Quality management System in line with ISO-9001 : 2000 at High Explosive Factory, Kirkee,
Implementing Quality management System in line with ISO-9001 : 2000 at TechNova Imaging Systems Ltd., Taloja,
Implementing Quality management System in line with ISO-9001 : 2000 at Abwed Infotech Pvt. Ltd.,
Implementing Quality management System in line with ISO-9001 : 2000 at Sankalpan Architecture Pvt. Ltd., Mumbai

Training Programmes :

Title of the Programme	*Dates*	*Organisation*
2-Day Programme on ISO- 9001 : 2002 QMS	4-5 June, 2002	General Training Programme
Six Sigma Awareness Programme for Sr. Executives	4-5 May, 2002, 27-28 July, 2002, 7-8 Sept, 2002, 15-16 Nov, 2002	M/S Tech Nova Imaging System Ltd.
One Session conducted for Standardized Design Practices for two days	17-18 April, 2002	Greaves Ltd.
Training programme on Six Sigma	7-11 October, 2002 6-10 January, 2003	Johnson & Johnson Ltd., Mumbai

SQC & OR (T&P) Unit, Kolkata

Research Activities:

Theoretical research on testing exponentiality against the alternative of "New Worse than Better than Used in Expectation (NWBUE)" family of life distributions has been undertaken. The test has been found to be consistent and the asymptotic distribution of the proposed test statistic has been obtained.

Theoretical research in deriving the reliability of Shared Load Parallel System is in progress. The current results in the area for a 2-unit system assume that the probability density function (p.d.f.) of the surviving unit at full load does not depend on the time spent on half load prior to failure. This does not reflect the reality in many instances. So, research work is in progress to derive the reliability of a 2-unit shared load parallel system in

the case when a unit fails and the p.d.f. of the surviving unit at full load depends on the time spent on half load period.

Applied research on modeling number of defects per unit time for a software development process was undertaken. The issue of characterizing the current software development process in terms of average number of defects per unit time was examined. The characteristic could be adequately modeled using a negative binomial distribution. Subsequently, standard for average number of defects/unit time was worked out and the control limits for the same were established.

The modeling of the measurement process of earing percent for closure stock in an Indian Aluminium Industrial unit forms another area of applied research in this unit. A linear model was successfully used to model the measurement process of earing. Significant effects were located and corrective actions to reduce uncertainty were proposed. This resulted in an overall improvement of the measurement system. Estimates of the overall measurement variability (Uncertainty) and errors due to repeatability and reproducibility after implementation of the suggested corrections were estimated in course of this work.

Other Academic Activities:

Teaching:

Teaching in M.Tech. (QROR) 1st year Engineering stream, 1st year Statistics stream and 2nd year combined stream continued during the year under review. 9 students passed out after successfully completing the course and 14 students joined the first year of the course during the same period.

Faculty assistance has been provided to the 2nd year M.Stat. (SQC and OR) programme.

A four weeks' training programme on Operations Research has been conducted for Batch XXV of Indian Statistical Service Probationers during 26 August – 20 Sept. 2002. Twenty seven officers attended the programme.

Faculty assistance has been provided to the 56th term ISEC Regular Course on Statistical Quality Control (SQC) and Operations Research (OR) during November 2002 – January 2003. Also, the specialization courses on SQC and OR for the same batch were conducted at the SQC-OR (T&P) Unit during January – March 2003.

Externally Funded Projects:

1. Development of a sampling plan to estimate non-cane material in sugar cane used by a sugar factory in Maharastra (under the aegis of ECS Ltd., Mumbai).
   The sampling plan developed is currently in use.

2. Improvement of productivity, yield and purity of a chemical (used as catalytic agent) by studying the effect of several process variables using Response Surface Methodology (under the aegis of ECS Ltd., Mumbai).

Training Programmes:

Title	*Date/Month*	*Organization*
Advanced Response Surface Methodology	25-26 July'02	ECS Ltd., Mumbai
Statistical Process Control Techniques	11 - 13 November, 2002	Tata Iron and Steel Co., Ltd., Jamshedpur.
Statistical Process Control and On-line Quality Control Techniques	12 - 14 November, 2002.	Ordnance Factories Staff Collage, Nagpur
Statistical Quality Control	26 - 28 November, 2002	The Metal and Steel Factory, Ministry of Defence, Ishapore

INDIAN STATISTICAL INSTITUTE

Library, Documentation and Information Sciences Division

Documentation Research and Training Centre (DRTC), Bangalore

The DRTC regularly conducts a course of 24 months duration leading to the award "Associateship in Documentation and Information Science" (ADIS). This award is recognized by the Govt. of India and several other universities as equivalent to a Master's Degree in Library and Information Science.

Apart from the research, teaching and training activities, DRTC also has the following programmes: (i) Advisory Services Programme, (ii) Publication Programme, (iii) Employment Information Programme, (iv) Continuing Educational and Training Programme and (v) Faculty Development Programme.

Research Activities

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

(i) The application of the "Modern scientific management techniques to the planning and management of information system, centers and services, (ii) The study of Internet technology and its applications, library automation and digital libraries, (iii) The development of bibliometric and scientometric measures for evaluating the use of library and information services and scientific output respectively.

Library (Kolkata)

The Central Library at ISI, Kolkata has undergone telltale changes over the year 2002-2003. A major part of the transformation concerns the physical appearance of the library itself. The stack areas in all three floors, and especially the Reports and Records Unit, have been cleaned and exhaustively redesigned. A new Reading Room, along with a circulation counter, has been created for the 3rd floor to accommodate users visiting the Reports & Records Unit. The Reading Rooms for the 1st and 2nd floors have also been renovated along with the Circulation Counters. The Conference Room of the library has been newly designed.

Along with the physical changes, the library staff has initiated significant improvements in the quality of services rendered. A major achievement is the preparation of a Computerized Catalogue for the Reports & Records Unit. Another important step has been the rapid upgradation of all computerized services provided by the library. The installation of the latest version of LibSys helped in the process. In particular, users are now being automatically intimated about their library dues. Besides, any user has continuous access to his/her account in the library over the web.

A very major achievement during the year was a complete stock verification of library books and journals. A detailed report, placed before the Director, revealed that the size of losses incurred by the library over its long existence has stayed within healthy limits.

With the addition of 1679 books and 2108 bound volumes of journals to the stock, the total collection of the Library rose to 222082.

A summary of Unit wise activities follows:

Acquisition Unit

The Unit accessioned 1679 books during the period under report, out of which 1224 books were purchased and 455 books were received on complimentary basis, and 139 books were acquired from NBHM Grant. The Unit accessioned 231 books, which were purchased out of Project funds.

Periodicals Unit

The Unit received 7300 loose issues of journals. The Unit also placed orders for 460 journals in 2002-2003. Besides this, the Unit received a number of journals on exchange. The Unit completed the binding of 2108 journals. Automated Circulation System for journals has been activated since January 2003. The Reading Room area has been provided with OPAC terminals.

Three major online databases have been subscribed to under consortium plan- MathSci Net, Econlit and Science Direct for full text journals.

Circulation & Stack Maintenance Unit

The Unit issued 95798 books and other documents to the users on loan and reference. The total membership of the Library was 3237. The members include ISI staff, Research Scholars, Project Assistants, internal students, ISEC Trainees as well as outside students and institute members. Special permission to use the Library for a short period was issued to 758 readers.

Inter-Library Loan : 12 books and journals were borrowed from other libraries and 18 books and journals were loaned to other libraries under the inter-library loan arrangement.

The Unit processed 1229 books for binding. Lamination and de-acidification of rare collections had been taken up for conservation of documents. As a part of computerization of Library functions, the Unit completed the process of issue/return of documents with barcoding of documents and membership cards.

Reports & Records Unit

The Unit processed 184 titles and 536 titles were issued to users.

Circulating Library

The Workers' Circulating Library acquired 135 new titles bringing the total collection to 37445, and issued approximately 20135 books to the members.

Technical Processing Unit

The Unit classified and catalogued 2035 new books and added to the LIBSYS database. The Unit issued 12 issues of Current Additions to the Library. *Current Additions to the Library* is now available online.

Documentation Unit

The Unit had issued current contents list services to the users on the following group of subjects: a) Statistics and Mathematics, (b) Electronics and Communications Science, (c) Geology, (d) Life Science, (e) Economics, (f) Recent additions of books to the ISI Library. It prepared a searchable bibliographic database on scientific contributions made by the ISI workers in various subject fields since 1934 using CDS/ISIS. So far, 3467 entries are available in the Database.

Reprography & Photography Unit

The Unit provided 553244 photocopies, 3538 photographic enlargements, 39000 electronic prints, 2919 frames of photographs including lecture slides and copy negatives and 1493 pages of color and B/W computer output during the year.

North-Eastern Region NBHM Collection

The Library is recognized by the Eastern and North–Eastern Regional Centre of the National Board for Higher Mathematics (NBHM). The Library received the NBHM grants for development of collection (Books and

Journals) in the areas of Mathematics, Applied Mathematics, Statistics, and Theoretical Computer Sciences. A Consortium had also been formed with the Universities and Institutions of the North-Eastern Region providing on-line access to database of Mathematical Reviews (MathSci net). The Chief Librarian acted as the Coordinator to the Consortium.

Library (Delhi)

The Delhi Centre of Indian Statistical Institute, maintains an academic library, which aims to be a leading library in the fields of Mathematics, Statistics, Economics, Econometrics, Operations Research and Statistical Quality Control. The Library caters, mainly to the needs of bonafied students, scholars and staff of the Institute. However, it is also open for reference to academic and research users of other educational and scientific institutions of the city, and its neighbouring regions. During the period under review, following were the activities of the library:

Acquisition

Library purchased 691 books, during the period April 1, 2002 to March 31, 2003 both from the regular and NBHM funds and received 106 books as gift. It added 532 bound journals to the stock, thus raising the stock to 39933 volumes.

Periodicals

During the year the library subscribed to 255 titles of journals, both foreign as well as Indian. 532 sets of loose issues of periodicals duly bound have been added to the stock. The library renewed the Consortium agreement for MathSciNet with the American Mathematical Society and Academic membership with the Society for the Industrial and Applied Mathematics (SIAM).

Subscription to online database of EconLit and Elsevier ScienceDirect for full text journals has been made under consortium plan.

Circulation Services

During the year, 108 members availed theemselves of the lending facilities as permanent members of the library and 670 members of reference facilities as temporary members of the library. More than 3000 publications have been circulated among the members. 34 publications were borrowed on ILL from the neighbouring Institute libraries and 12 books were lent out to other Institutes under the same program.

Reprographic Services

Photo copies 51910 pages were made and provided to both the permanent and temporary members of the library. Photocopying facilities were also extended to the research scholars of neighbouring Institutes on a nominal charge of Rs.0-50p. per exposure.

Other activities

NBHM Regional Library

The Delhi Centre Library, being the regional library to serve the Northern Region, got a grant from National Board for Higher Mathematics, Department of Energy, Government of India, for strengthening its collection in the field of Mathematics and Statistics.

To keep the libraries of the northern region informed of the contents of the latest journals in Mathematics and Statistics, a monthly issue of the "Current Contents", obtained by photocopying the contents page of each journal received at ISI, Delhi Centre Library, during a specified period is prepared and distributed to the Department of Mathematics of each university in the northern region.

Similarly, to keep the users informed about the new books acquired at the ISI, Delhi Centre Library, a quarterly issue of "Newsletter" is produced and widely distributed. An electronic issue is also maintained on the Net and sent to those who desire to receive it through e-mail. Delhi Centre Library has undertaken the project of barcoding its collection.

Library (Bangalore)

Book Acquision

During the period 430 books were purchased and 100 were received *gratis*.

Technical Processing

About 6270 books were classified and catalogued during the period.

Circulation Statistics

During the period library facilities were enjoyed by 510 users. 313 of them availed of the lending facilities, 8 visiting professors of different units of ISI were also provided with lending facilities. A total of about 17400 books and periodicals were circulated by the library. The in-house use of books and periodicals was around 3900.

Inter Library Loan Service

About 80 inter library loan transactions were registered.

Reprographic Service

Library provided 210000 photocopies to the users during the period.

Documentation Service

The following publications were brought out regularly from the library : (i) Bimonthly list of books, (ii) Monthly list of current periodicals, (iii) Current content of journals, iv) Online Public Access Catalogue (OPAC)

Computer and Statistical Services Centre

The Computer and Statistical Services Centre (CSSC) manages the central computing facilities of the Institute at Kolkata. Internet facilities are also managed by CSSC. The centre serves about 500 users including the students, research scholars and scientific workers with the inhouse computer systems SUN E 3000 server, DEC Alpha 4100 server and IBM AS-400 server. There are also 16 SUN BLADE Workstations for the students. The servers can be accessed from different terminal rooms equpped with PCs. The campuswide network is also maintained under the supervision of CSSC. This year CSSC has procured 110 P4 PCs to be given to the different units of ISI, Kolkata.

Besides the standard compilers, other important application softwares available in SUN server are SAS, BMDP, SHAZAM, TSP, Matlab, Mathematica, S-Plus and ARC-INFO based GIS system. GIS has been purchased during the period under review.

CSSC provides Statistical and Computational consultancy to its users. The staff members of CSSC take part in teaching different courses in various programmes of the Institute. They also supervise projects of the students of M.Tech. (CS) and M.Tech. (QROR) courses of ISI. The centre also extends computing facilities to the MCA and B.Tech students of other colleges and institutes. The final semester projects of these students are supervised either by the staff members of CSSC or by other faculty members of the institute.

The staff members of CSSC participate in the research projects of other units as well.

4. INTERNALLY/EXTERNALLY FUNDED PROJECTS

INTERNALLY FUNDED PROJECTS

Ongoing Projects

1. Name of the Project : Analysis of fMRI Data and Human Brain Mapping
   Principal Investigator : S. Purkayastha
   Units involved : Stat.-Math., Applied Statistics and Computer Vision & Pattern Recognition

2. Name of the Project : Analysis of SODAR Data
   Project leader : A. Pal
   Unit involved : Applied Statistics

3. Name of the Project : Air Pollution Modelling
   Project leader : R. Roychowdhury
   Unit involved : Applied Statistics

4. Name of the Project : Approximation to High-dimensional Model Selection Criteria and Evaluation of Performance.
   Project leader : T. Samanta
   Unit involved : Applied Statistics

5. Name of the Project : Contribution of Boolean Functions of Cryptographic Importance
   Project leader : B. K. Roy
   Unit involved : Applied Statistics

6. Name of the Project : Optimal Routing Strategies for Integrated Wireless and Terrestrial Networks
   Principal investigators : B. P. Sinha and N. Das
   Unit involved : Advanced Computing and Microelectronics

7.. Name of the Project : Routing and Initialization for Mobile Wireless Ad-hoc Networks
   Principal investigators : J. Dattagupta and N. Das
   Unit involved : Advanced Computing and Microelectronics

8.. Name of the Project : Multi-layer VLSI Routing
   Principal investigator : S. Sur-Kolay
   Unit involved : Advanced Computing and Microelectronics

9. Name of the Project : Checkpointing in Distributed Systems
   Principal investigator : K. Mukhopadhyaya
   Unit involved : Advanced Computing and Microelectronics

10. Name of the Project : Handwritten Character Recognition
    Principal investigator : U. Bhattacharya
    Unit involved : Computer Vision and Pattern Recognition

11. Name of the Project : Functional Magnetic Resonance Imaging
    Principal investigator : S. Palit
    Unit involved : Computer Vision and Pattern Recognition

12. Name of the Project: Natural Language Processing
    Principal investigator : B.B. Chaudhuri.
    Unit involved : Computer Vision and Pattern Recognition

13. Name of the Project: Speech and Signal Processing.
Principal investigator : B.B. Chaudhuri.
Unit involved : Computer Vision and Pattern Recognition

14. Name of the Project: Development of Multi-scale Morphological Tools for Image Processing.
Principal investigator : B. Chanda.
Unit involved : Electronics and Communication Sciences

15. Name of the Project : Analysis of Remotely-sensed Data for Resource Management.
Principal investigators : P. Pal and B. Chanda.
Unit involved : Electronics and Communication Sciences

16. Name of the Project : Image Information Retrieval.
Principal investigator : D. P. Mukherjee.
Unit involved : Electronics and Communication Sciences

17. Name of the Project : Cloud Motion Vector Estimation using Water Vapor Imageries.
Principal investigator : A. K. De.
Unit involved : Electronics and Communication Sciences

18. Name of the Project : Prediction of Meteorological Behavior of the Atmosphere Using artificial neural networks.
Principal investigators : J. Das, S. Pal and N. R. Pal
Unit involved : Electronics and Communication Sciences

19. Name of the Project : Multi-scale image segmentation, representation and storage for Content Based Image Retrieval (CBIR)
Principal investigators : M. K. Kundu
Unit(s) involved : Machine Intelligence and Advanced Computing & Microelectronics

20. Name of the Project : Soft knowledge-based network for data mining
Principal investigators : S. Mitra and S. K. Pal
Unit involved : Machine Intelligence

21. Name of the Project : Digital watermarking and image/video compression using wavelet
Principal investigator : M. K. Kundu
Unit involved : : Machine Intelligence

22. Name of the Project : Data condensation, Classification and rule generation for data mining
Principal investigators : C. A. Murthy and S. K. Pal
Unit involved :Machine Intelligence

23. Name of the Project : VC dimension, neural networks and wavelets.
Principal investigators : C. A. Murthy and S. K. Pal
Unit involved : : Machine Intelligence

24. Name of the Project : Modeling and enhancing the performance of genetic algorithms
Principal investigators : A. Ghosh and S. K. Pal
Unit involved : : Machine Intelligence

25. Name of the Project : Integration of spline and neural network methodologies for multi-resolution classification
Principal investigator : S. N. Biswas
Unit involved : Machine Intelligence

26. Name of the Project : Evolution of the Nallamalai fold belt - fault reactivation and kinematics in an intracratonic fold belt.
Project coordinator : D. Saha
Unit involved : Geological Studies

27. Name of the Project : Precambrian geodynamics in east Indian shield : Structural, petrological and geochronological constraints.
Project coordinator : S. Bhattacharya
Unit involved : Geological Studies

28. Name of the Project : Mesozoic vertebrates from the Gondwana Basins of India with special emphasis on Exploration, retrieval and analysis
Project coordinators : S. Bandyopadhyay and D. P. Sengupta
Unit involved : Geological Studies

29. Name of the Project : Sedimentology and palaeoclimatology of the Upper Gondwana Succession in Central India
Project coordinators : P. Ghosh, P.K. Maulik, S. N. Sarkar and T. Chakraborty
Unit involved : Geological Studies

30. Name of the Project : Physicochemical Studies of Self-Organised Systems using Surfactant(s)/Cosurfactant(s)/Oils(s)/Polar Solvents (aqueous and non-aqueous)
Project coordinator : B.K. Paul
Unit involved : Geological Studies

31. Name of the Project : National Workshop on Nonlinear Physics
Project Coordinators : K. Kumar and R. Roychoudhury
Unit involved : Physics and Applied Mathematics

32. Name of the Project : Application of Symmetry Algebras to some problems of Quantum Physics
Project coordinators : P. Roy, B. Roy and R. Roychoudhury
Unit involved : Physics and Applied Mathematics

33. Name of the Project : Interacting Fock Space
Principal investigator : P. K. Das
Collaborators : Luigi Accardi and Marcolino Nhani
Unit involved : Physics and Applied Mathematics

34. Name of the Project : Wave Scattering & Associated Mathematical Techniques
Principal investigator : B. N. Mandal
Unit involved : Physics and Applied Mathematics

35. Name of the Project : The Status of QGP in High Energy Nuclear Physics : Past, Present & Future.
Principal investigator : S. Bhattacharyya
Unit involved : Physics and Applied Mathematics

36. Name of the Project : Interaction of flow and sediment suspension over bedform structures : experimental and theoretical studies
Principal investigator : B. S. Mazumder
Unit involved : Physics and Applied Mathematics

37. Name of the Project : Studies on sustainability criteria in rainfed eastern plateau area
Principal investigator : D.K. Bagchi
Unit involved : Agricultural Sciences

38. Name of the Project : Rice area characterization using satellite imagery and geographical information system tools.
Principal investigator : P. Banik
Unit involved : Agricultural Sciences

39. Name of the Project : Studies on the ecophysiology, community structure and biomass estimation of mangroves, and biology, conservation, propagation and utilization of palms.
Principal investigator : M. Ghosh
Unit involved : Agricultural Sciences

40. Name of the Project : Studies on insect pest olfaction
Principal investigator : A. Goswami
Unit involved : Agricultural Sciences

41. Name of the Project : Studies on the ecology, conservation, propagation and utilization of palms with special reference to rattans (North East Project).
Principal investigator : M. Ghosh
Unit involved : Agricultural Sciences

42. Name of the Project : Modernization and Cardiovascular Health in the Sikkim Himalaya
Principal investigator : B. Mukhopadhyay
Unit involved : Anthropology and Human Genetics

43. Name of the Project : Gene-Environment Interaction in Oral cancer
Principal investigator : B. Roy
Unit involved : Anthropology and Human Genetics

44. Name of the Project : Growth as a mirror of conditions of society
Principal investigator : P. Dasgupta
Unit involved : Anthropology and Human Genetics

45. Name of the Project : Population structure and microevolution – the effect of mating patterns on genetic differentiation among the Adi-Pasi tribe
Principal investigator : T.S. Vasulu
Unit involved : Anthropology and Human Genetics

46. Name of the Project : Health of the Tibetan Refugees in Exile in India.
Principal investigator : R. Gupta
Unit involved : Anthropology and Human Genetics

47. Name of the Project : Origin and genetic composition of the Lyngngam.
Principal investigator : B.M. Reddy
Unit involved : Anthropology and Human Genetics

48. Name of the Project : DNA polymorphisms in the castes and tribes of Andhra Pradesh
Principal investigator : B.M. Reddy
Unit involved : Anthropology and Human Genetics

49. Name of the Project :Health and Disease : comparison between two ecological settings
Principal investigator : S. K. Roy
Unit involved : Anthropology and Human Genetics

50. Name of the Project : Genetic Epidemiology & Diversity in Indian Populations
Principal investigator : P. P. Majumder
Unit involved : Anthropology and Human Genetics