Seventieth
Annual Report

April 2001 - March 2002

INDIAN STATISTICAL INSTITUTE
203 Barrackpore Trunk Road
Kolkata - 700 108

E. CHAIRMAN AND OTHER MEMBERS OF THE COUNCIL AS ON MARCH 31, 2002

esident : Prof. M.G.K. Menon, FRS
Governor, Reserve Bank of India
FNA

Representatives of Government of India

3. Dr. S. Ray, Director General & CEO, National Sample Survey Organisation, Ministry of Statistics & Programme Implementation.
4. Shri P. Sinha, Additional Secretary & Financial Adviser (Statistics), Ministry of Statistics & Programme Implementation.
5. Dr. R. B. Barman, Executive Director, Deptt. of Statistical Analysis & Computer Services, Reserve Bank of India.

Scientists not employed in the Institute
Representative of ICSSR

6. Dr. Bhaskar Chatterjee, Member Secretary (In-Charge), Indian Council of Social Science Research.

Representatives of INSA

7. Prof. S.K. Malik, Chairman, CAS in Mathematics, Punjab University, Chandigarh.
8. Prof. D. Dutta Majumder, Professor-Emeritus, Indian Statistical Institute, Kolkata.
9. Prof. K.R. Parthasarathy, Emeritus Scientist, Indian Statistical Institute, New Delhi.
10. Prof. M.R.S. Rao, Chairman, Department of Bio-Chemistry, Indian Institute of Science, Bangalore.

Representative of the Planning Commission

11. Shri K.L. Dutta, Joint Adviser (PP), Planning Commission, New Delhi.

Representative of the University Grants Commission

12. Prof. J.V. Deshpande, Professor, Department of Statistics, University of Pune, Pune.

Scientists co-opted by the council

13. Dr. M. Vidyasagar, Executive Vice President, Tata Consultancy Services, Secunderabad.
14. Prof. Sushanta Dattagupta, Director, S.N. Bose National Centre for Basic Sciences, Kolkata.

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

15. Prof. Deb Kumar Bose, Former Chairman, West Bengal Pollution Control Board, Kolkata.
16. Prof Prabuddha Nath Roy, Former Pro-Vice Chancellor (Academic), Calcutta University, Kolkata.
17. Shri B.K. Pal, Former Head, SQC & OR Division, Indian Statistical Institute, Bangalore.

Elected representatives of the employees of the Institute

18. Dr. Deba Prasad Mandal, Representative of the Scientific Workers.
19. Shri C. Periasamy, Representative of the Non-Scientific Workers.

Officers of the Institute

20. Dr. Rajeeva L. Karandikar, Professor-in-Charge, Theoretical Statistics & Mathematics Division.
21. Prof. Bimal Kr. Roy, Professor-in-Charge, Applied Statistics Division.
22. Prof. Satya Ranjan Chakravarty, Professor-in-Charge, Social Sciences Division.
23. Prof Himadri Pai Majumder, Professor-in-Charge, Physics and Earth Sciences Division.
24. Prof. Ranjan Gupta, Professor-in-Charge, Biological Sciences Division.
25. Prof. Nikhil Ranjan Pal, Professor-in-Charge, Computer & Communication Sciences Division.
26. Shri K.M. Date, Head, Statistical Quality Control & Operations Research Division.
27. Prof. Alok Dey, Head, Delhi Centre.
28. Prof. Gadadhar Misra, Head, Bangalore Centre.
29. Dr P.S.S.N.V.P. Rao, Dean of Studies.

Non-Member Secretary

Shri D. C. Bandyopadhyay, Chief Administrative Officer.

INDIAN STATISTICAL INSTITUTE

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

INDIAN STATISTICAL INSTITUTE
SEVENTIETH ANNUAL REPORT
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CONTENTS

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 and Anthropological Survey of India) and subsequent interactions with him led to the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists was picked up by him to start the Statistical Laboratory, in the Department of Physics, Presidency College, Calcutta, where he was a Professor.

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

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

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

The ISI also played a pioneering role in starting the Statistical Quality Control (SQC) movement in India by organising a 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 initiated the International Statistical Education Centre (ISEC), Calcutta, jointly with ISI, 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 2001-2002 in the Indian Statistical Institute had its share of changes, though at a slow pace. But then resistance to change is a common human foible. I personally would like to see the changes take place somewhat faster, helping the Institute to keep pace with the rest of the country and the world. The building programme of the Institute (with four projects including the Academic Building Phase I and a total project cost of nearly Rupees eight and half crores) got off to a start. Also, the major repairs of various buildings, though unfortunately slow, are progressing; the Guest House renovation and the construction of the new gate for the main campus are almost complete. Furthermore we have been able to enlist the cooperation of the Bharat Sanchar Nigam Limited in installing fibre-optic cables with a new internet connection paving the way for improved electronic communications. These are a few physical changes in the campus which will make it look somewhat modern and be ready for the challenges of the new century.

As a part of the ongoing process of updating of various training programmes, the Institute recently revised the M.Stat and M.Tech curricula. For example, a new specialisation in Actuarial Statistics has been introduced in M.Stat.; similarly in M.Tech (Computer Science) topics like Internet and Multimedia technology and Advanced Cryptology find their place. This will enable the graduating students to sample from an enlarged panorama of job opportunities in the fast-changing market scenario. We must continuously undertake these exercises – look at the scene in the technologically skilled job market and upgrade/reorient our training programmes appropriately (of course, consistent with our goals and parameters) so as to keep pace with the demand. This however, should not in any way detract from our main goal, namely that of doing research at the highest academic level. Both goals can be achieved simultaneously and the Institute should strive for that. In my last convocation address, I had mentioned a kind of change afflicting young people of today – that of not taking the challenging path of research and pursuing the newly emerging areas. The reorientation of the above courses is, in a sense, an attempt to address the problem – "if you can't beat them, join them".

The Institute continues with the major externally funded projects – in Human Genetics (funded by Department of Biotechnology, in Cryptography (funded by Defence Research and Development Organisation and the Indian Navy) and the first steps have been taken to initiate new projects with the various Laboratories of Indian Space Research Organisation and Indira Gandhi Centre for Atomic Research, Kalpakkam.

The Institute should consider preparing projects (externally or internally – funded) in the various areas of research in a multi-institutional mode. Aside from the fact that this will relieve the Institute of some financial pressure, it will go a long way towards bringing the scientists into contact with each other and bring forth cross-fertilisation of ideas. The co-operation programmes may be in regional or national mode – like the project entitled " Computational Intelligence-based Remote Welding System" initiated by Professor N. R. Pal of ECSU with Indira Gandhi Centre for Atomic Research (funded by Board of Research in Nuclear Sciences), and the one by Professor P. P. Majumder with Saha Institute of Nuclear Physics and Indian Institute of Chemical Biology (funded by the Chatterjee Group). These examples need to be emulated and multiplied.

Amongst the new initiatives in the relevant year, I would like to mention : (i) the transfer of Optical Character Recognition technology developed by CVPR unit to Electronics Research and Development Corporation of India, Noida and I.I.T.,Guwahati, (ii) completion of the Multimedia project for instruction of Statistics and (iii) the beginning of the intake of young faculty in the new positions of Assistant Professor. The major programmes that have been satisfactorily completed are : (i) the "Health Sector Reforms" funded by the European Union and executed by Prof. S. Guha Roy, (ii) "Environmental Management Capacity Building Technical Assistance Project : Environmental Economics Component" funded by the World Bank and executed by Prof. Robin Mukherjee and (iii) "Compilation and Optimization for Reconfigurable Co-processors" funded by Indo-French Centre for the promotion of Advanced Research and executed by Prof. B. B. Bhattacharya. The Institute lauds their untiring efforts and their contributions in these major projects.

The infrastructure of the Kolkata Campus at the Headquarters of the Institute needs major overhaul and renewal. For many reasons – known or unknown, the buildings and facilities seem to have been added without

proper projections or planning. This has created crisis in power/water distribution and in other essential services. These problems have to be addressed scientifically : a logical growth projection of the Institute made and the consequent infrastructural problems addressed. That remains the next challenge.

Another matter which had been vexing for a long time is that of the merger of the accounts of Printing & Publication Unit. After the redeployment of some of the personnel and fulfillment of some other details, that goal is now achieved, and as an icing on the cake we have also succeeded in printing two issues of Sankhya in-house after nearly nine years.

Finally, I am happy to announce that our colleagues Professor P. P. Majumder of Biological Sciences Division has been awarded Ranbaxy Science Foundation Award in Applied Medical Sciences, Professor B. V. Rajarama Bhat of Theoretical Statistics & Mathematics Division in Bangalore has been awarded B. M. Birla Award and Professor S. K. Pal of the Computer & Communication Sciences Division received the Syed Husain Zaheer Medal from INSA. The Institute is very proud of these achievements.

March 31, 2002

K. B. Sinha

Part I. Teaching and 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 2001-2002 is given below.

During the academic session 2001-2002 a total of 8064 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. (M-stream and 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, Research Fellowships in Statistics, Mathematics, Economics, Computer and Communication Sciences, Discrete Mathematics and Theoretical Computer Science, Physics and Applied Mathematics, Anthropology, Linguistics, Sociology, Demography and Library and Information Science. Admission tests were conducted at 24 different centres all over the country. A total of 5689 candidates appeared for the admission tests and a total of 433 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests, interview and the academic record, 171 candidates were offered admission to various courses during the academic session under review.

The annual examinations for all the regular courses of 2000-2001 were held in May-June 2001. The 2001-2002 academic session commenced on 1 August 2001.

Fifty five 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, Ddhanbad; Institute of Engineering & Management, Salt Lake, Calcutta; Regional Engineering College, Trichy; IIT, Guwahati; Institute of Technology, Bhubaneswar) received a two week/six week/six month M.C.A/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 Multimedia Laboratory was set up in 1999 with the objective of developing a multimedia-based teaching aid for introductory statistics. The module would contain five parts. Previously the introductory part had been designed and developed. The work done in 2000-01 was on the next two parts : Tabular/Graphical representation of data and Mean & Median. The module includes some narration with illustrations followed by interactive exercises and data analysis. Apart from this work, the Multimedia Lab. helped the ISI Website Committee in bringing about certain modifications to the ISI website. It also helped *Sankhya* in creating/cleaning/computerizing images for various issues of the journal.

Several students from ISI and other Institutions/Universities received training in the Multimedia Laboratory.

The number of candidates admitted to the different degree, diploma and training courses in 2001-2002 and the number of students who passed in the annual examinations in 2001 are given below :

NUMBER OF STUDENTS ADMITTED TO AND PASSED IN DIFFERENT COURSES

Sl. No.	Course	Number of Students who	
		Passed in the Annual Exam. In 2001	Enrolled in 2001-02
Degree			
01.	Bachelor of Statistics with Hons. (B.Stat. (Hons.))		
	First year	18	22
	Second year	18	18
	Third year	12	18
02.	Bachelor of Mathematics with Hons. (B. Math. (Hons.))		
	First year	7	13
	Second year	-	7
03.	Master of Statistics (M.Stat.)		
	First year	17	28
	Second year	29	29
04.	Master of Science in Quantitative Economics (M.S.(Q.E.))		
	First year	16	22
	Second year	13	23
05.	M.Tech. in Computer Science		
	First year	27	24
	Second year	29	27
06.	M.Tech. in Quality, Reliability & Operations Research		
	First year	9	14
	Second year	11	9
Certificate/Diploma			
07.	Course in Computer Programming & Applications		
	First year	4	-
	Second year	8	4
08.	Junior Diploma in Statistics (JDS)	2	-
	Senior Diploma in Statistics (SDS)	1	22
09.	Associateship in Documentation and Information Science (Bangalore)		
	First year	6	8
	Second year	6	6
10.	Junior & Senior Research Fellows and Research Associates in different disciplines	11	18
	Grand Total	244	312

Ph.D./D.Sc. Degrees

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

i) Suman Kumar Mitra : "On fractal based representation of images with applications to image processing". Supervisor : C.A. Murthy, ISI, Kolkata.

ii) Subhamoy Maitra : "Boolean functions with important cryptographic properties". Supervisor : Bimal K. Roy, ISI , Kolkata.

iii) M.Rajesh : "Some problems in homogenization"
Supervisor : S. Kesavan, IMSc, Chennai.

iv) Santanu Chakraborty : "Contributions to random iterations and dynamical systems".
Supervisor : B.V. Rao, ISI, Kolkata.

v) E.K. Narayanan : "Oscillating multipliers and Bochner-Riesz Means".
Supervisor : S. Thangavelu, ISI, Bangalore.

vi) Sandip Das : "Routing algorithms for channels, switchboxes and MCM's in VLSI Layout design".
Supervisor : Bhargab Bhattacharya, ISI, Kolkata.

vii) Saurabh Ghosh : "Mapping quantitative trait loci in humans : some statistical considerations".
Supervisor : P.P. Majumder, ISI Kolkata.

viii) Amalendu Krishna : "Zero cycles and K-theory on normal surfaces".
Supervisor : V. Srinivas, TIFR, Mumbai.

ix) Anindya Bhattacharya : "Essays on cooperative behaviour and collective action"
Supervisor : Bhaskar Dutta, ISI, Delhi.

x) Chandranath Pal : "On some optimal tests in finite mixtures : constructions and applications".
Supervisor : Ashis Sengupta, ISI, Kolkata

xi) Umesh Perdoor
Srinivas Adiga : "On quantitative evaluation of histo-pathological images obtained using confocal microscope".
Supervisor : B.B. Chaudhuri, ISI, Kolkata.

(B) Ph.D. Degree awarded by other Universities to the Research Fellows of the Institute :

i) Sarbani Patranabis Deb : "Purana (Poterozoic) stratigraphy and sedimentation in the eastern part of the Chattisgarh basin; a fan delta motif".
(Awarded by Jadavpur University)

ii) Rajib Kar : "Structural setting and P-T-t, path of the Eastern Ghats Granulites adjacent to Singhbhum Craton in an area around Jenapore, Orissa, with special reference to the origin of Charnockites".
(Awarded by Calcutta University)

iii) Niladri Sekhar Dash : "A Corpus-based computational analysis of the Bangla language".
(Awarded by Calcutta University)

International Statistical Education Centre (ISEC), Kolkata

The International Statistical Education Centre was established in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a Joint Board of Directors. Professor P.C. Mahalanobis was

the Chairman since the inception of the Centre in 1950 until his death in 1972. Since then Professor C.R. Rao has been the Chairman of this 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.

The Centre offers a ten-month (June to March) Regular Course of training every year. The Course is divided into two parts. The first eight months are devoted to training on general statistical methods including a six-week training in Official Statistical Systems conducted by the Central Statistical Organisation, Government of India, New Delhi. During the remaining two months, each trainee specializes in one selected branch of applied statistics, like Large Scale Surveys, Data Processing, Economic Planning, Statistical Quality Control and Operations Research and Vital Statistics and Demography. The course comprises lectures, practical work and assignments, field visits, and guided reading. In addition to the Regular Course, a few persons are admitted on an individual basis, for special courses of varying durations and in different subject-fields.

ISEC successfully completed the training programme of the 55th term of the Regular Course during the year under review. There were twenty four trainees from eleven countries, viz. Sri Lanka (1), Maldives (1), Bhutan (1), Myanmar (2), Kenya (1), Gambia (3), Zambia (2), S.R. of Vietnam (1), Seychelles (1), Kazakhstan (4), LAO PDR (1), Papua New Guinea (1), Mauritius (1), Oman (1) and Iran (2). All of them have successfully completed the course and have been awarded Statistical Training Diplomas. Nineteen 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) and five trainees were nominated by their respective employers. Besides, there were 9 trainees from different countries in the Special Course on Sampling and Data Analysis Techniques.

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).

Given below are the details regarding the registered candidates for the September 2001 term.

Examination	No. Registered	No. Appeared	No. Passed
1. Junior Diploma in Statistics (JDS)	91	45	06
2. Senior Diploma in Statistics (SDS)	22	13	01

Preparation of the model-answer booklets for the compulsory papers in Senior Diploma in Statistics and two papers of Junior Diploma in Statistics is also under way.

The cumulative total number of candidates who have qualified for the award of the Diplomas in the Professional Examinations in Statistics is 288.

2. CONVOCATION

Thirty Sixth Convocation

Indian Statistical Institute held its thirty sixth 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 January 15, 2002.

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. Bimal Jalan, Governor, Reserve Bank of India 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	11
Master of Technology (M.Tech.) in Computer Science	29
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	11
Master of Statistics (M.Stat.)	29
Master of Science (M.S.) in Quantitative Economics	13
Bachelor of Statistics (Honours) {B.Stat.(Hons.)}	12
Associateship in Documentation and Information Science	6
Diploma in Computer Programming and Applications	8
Professional Examinations in Statistics :	
Junior Diploma in Statistics	2
Senior Diploma in Statistics	1
Total :	122

Awards

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

   Karthik, S.

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

   B.Stat. (Hons.) : Souvik Ghosh

INDIAN STATISTICAL INSTITUTE

M.Stat.	:	Tathagata Basak
M.S. (QE)	:	Sayantani Ghosh

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

Nabin Tewari

4. M.N. Murthy Memorial Prize for research work done in Applied Statistics, for 1998-1999 :

Amit Mitra (Reserve Bank of India, Mumbai)

5. Raja Rao Memorial Prize for research work done in the areas Survey Methodology/ Econometrics/Demography, for 2001-2002 :

M. Alagarajan (Bharathiar University, Coimbatore)

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.

Computer networking within the Institute at Kolkata has been completed 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 faculty of the Division takes a major part in the teaching of Mathematics, Probability, Statistics and Theoretical Computer Science to the B.Stat.(Hons.), B. Math. (Hons.), M.Stat. and M.Tech. students of the Institute. Courses are also run for research fellows and there are regular seminar activities all round the year. Yet other teaching programmes, in which the members of the Division take part are the six-month course of the International Statistical Education Centre and the UGC refresher course for college/university teachers. Apart from these, there are courses for the ISS (Indian Statistical Service) Probationary Officers and various summer and winter instructional schools that the Institute holds from time to time. The Kolkata unit has also taken the responsibility of the NBHM Nurture-Programme for the 1998-2002 batch. A number of faculty members is engaged in the editorial functions of Sankhya and in the administration of the Mathematics Olympiad Project of the NBHM at the regional and national levels. Under the sponsorship of the National Board for Higher Mathematics, one-day seminars on some basic areas in modern mathematics were organized in seven Calcutta colleges during the year. The lectures in these seminars were delivered by the faculty members of the Stat-Math Unit, Kolkata and the Department of Pure Mathematics of the Calcutta University.

Stat-Math Unit, Kolkata

The unit is actively engaged in research in many areas of Statistics, Probability, Mathematics and Theoretical Computer Science. An account of the active areas of research of the unit, major work done and projects undertaken during the year is given below.

Research Areas

Theoretical Statistics

Asymptotic theory in Statistics, Sequential Analysis, Bayesian Inference, Ranking and Selection, Multivariate Analysis, *M*-estimation, Asymptotic inference, specially in dependent models, Non-parametric Inference, Inference in Stochastic Processes, Directional Data Analysis, Linear Models, Optimal Designs and other aspects of experimental designs, Group Testing Designs, W^* matrices, Survey Sampling, Survival Analysis, Time Series Analysis, Bootstrap, Jackknife and other resampling techniques, Central limit theorem, Edgeworth expansions, Strong law of large numbers, Sequential estimation, especially second order properties of estimates, Parametric and nonparametric regression techniques and related topics, Bayesian nonparametric statistics and estimation, Bayesian semiparametric inference and inference with many nuisance parameters, Robust Bayesian Analysis, Reliability theory, ARCH models, Large dimensional random matrices, Record values, Theory and applications of statistical and graph theoretic techniques to Social Sciences, Biostatistics, Epidemiological studies on AIDS and HPV infections, Human Brain Mapping.

Probability Theory and Stochastic Processes

Limit theorems, Rates of convergence and expansions, Markov Processes and Dynamical Systems, Polynomial Martingales, Random Walks, Percolation Theory, Probability inequalities, Martingale theory and Stochastic Calculus, Markov chain simulation.

Mathematics

Commutative Algebra, Geometry of Banach Spaces, Spectral Theory of Differential Operators, Non-Commutative Geometry, General Topology, Algebraic and Differential Topology, Topology with emphasis on Function spaces, Equivariant plus construction and acyclic maps, Gromov theory on partial differential relations, Quantum groups, Uncertainty principles on Nilpotent and Solvable Lie groups, Wiener Tauberian Theorems in Semisimple Lie groups, Equivariant Cobordism, Stochastic Differential Geometry, Descriptive Set Theory, Automata Theory, Theoretical Computer Science, Harmonic Analysis, Ergodic Theory, Functional Analysis, Operator Algebras, Differential Geometry, Spectra of Laplacians, Sediment Transport, Graphs and Semi-graphs, Combinatorics and Construction of Designs.

Major Contributions

Probability Theory and Stochastic Processes

In the regular probability theory seminar, recent results on the following topics were discussed: Empirical Processes, Decoupling, Bootstrap, Percolation theory, random iteration of quadratic maps and Random Matrices.

Statistics

Distribution of some geometric characteristics of industrially produced jobs was shown to be an extreme value distribution and control charts based on these were proposed under certain assumptions.

Studies related to envioronmental statistics indicate the systematic destruction of ozone in high altitude atmospheric region. The minimum ozone level is a very important criterion for this green planet. This level for future years was predicted by extreme value theory, for the polar region.

The limiting distribution of the set of eigenvalues was obtained for certain random matrices as the dimension goes to infinity.

Distribution of the infinite product of record values was obtained.

Simple estimators for ARCH parameters have been developed and their asymptotic properties derived.

General resampling results have been obtained for a large class of M_m estimators. In particular these include all standard resampling schemes and a huge class of common estimators. Results on resampling plans were also obtained for M estimators in nonregular models and for the L_1 regression estimate when standard conditions are not satisfied.

A strong consistency result for minimum contrast estimators has been proved under weak conditions that unifies the study of strong consistency of least square estimators in nonlinear regression models and MLEs in generalized linear models.

A Fourier based methodology has been developed for approximating arbitrary closed two-dimensional shapes that are originally known to be bilaterally symmetric. This technique has been applied to study the taxonomy of an extinct group of amphibians (order temnospondyli) in collaboration with Geological Studies Unit.

A technique based on two-parameter data perturbation was developed for sample moment matching in nonnegative kernel density estimation. It was shown that the moments calculated from the resulting tuned kernel density estimate can be made arbitrarily close to the raw sample moments without losing the nonparametric rate of convergence.

In the context of Design of Experiments, the study of distance optimality based on the idea of minimising the distance between the true parameter value and its estimate in a stochastic sense has been carried out in the one-way ANOVA model set up for estimating the full set of all elementary contrasts. Invoking weak super majorisation technique, the symmetrical or the most symmetrical allocation of treatments, depending on the divisibility of the number of experimental units by the number of treatments, turns out to be uniquely DS optimal.

In the combinatorial aspects of designs, some preliminary investigation on the bounds of possible sizes of the critical set which consists of the minimal partial information needed to reconstruct a combinatorial structure has been carried out in the context of orthogonal arrays constructed from mutually orthogonal Latin Squares.

Regression designs in the heteroscedastic set-up of Poisson Count Models were studied and optimal designs were characterized.

The problem of estimation of the common mean of two populations under differential cost structures was investigated.

For Rao-Hartley-Cochran sampling scheme the relationships among the size measures and the first and second order inclusion probabilities were studied.

Though RSS method of sampling is gaining momentum, it was observed that for estimation of a Bernoulli parameter, there exists the problem of non-negative variance estimation based on RSS.

Statistical methods in assessing agreement between a gold standard technique and a new technique were studied w.r.t. models, issues and tools. Such studies are useful to assess the acceptability of a new or a generic process, methodology and formulation in areas of laboratory performance, instrument or assay validation, method comparisons and the like.

Some new probabilistic models for DNA sequences have been developed and studied using data available on the Internet. The models generalize standard Hidden Markov Models and have been motivated by the underlying replication process generating copies of DNA sequences.

Some probabilistic optimization algorithms for computing robust and nonparametric multivariate estimates have been developed and studied. These algorithms are motivated by the classical idea of simulated annealing based on Gibbs sampler. The algorithms developed appear to be quite fast and effective in identifying global optimum for many optimization problems in robust and nonparametric multivariate analysis for which no good exact algorithms are known – especially in those cases that involve data with very large dimensions.

In collaboration with colleagues from Delhi, a paper on Random Oriented Trees: A Model of Drainage Networks has been prepared.

New W^* matrices were constructed and new results in group testing designs were obtained in collaboration with Applied Statistics Unit.

During the year under consideration, progress was also made on research on various theoretical as well as applied areas like Bayesian inference, Time Series, Central limit theorem, Random Matrices, Optimal designs, Human Brain Mapping, Bayesian Image analysis and Epidemiology of Malaria in an Endemic area in Kolkata. In the area of Sampling, work on utilisation of auxiliary information in sample selection and estimation was carried out. The problem of optimum allocation of sample size to strata was further discussed from a super-population point of view.

Mathematics:

Algebraic Topology: Deformation theory of algebraic structure is an important area initiated by Gerstenhebar. A deformation theory of 'dialgebras' which are a kind of binary quadratic algebras using dialgebra cohomology was developed. Investigations on various algebraic structures of the dialgebra complex which defines the above cohomology were also conducted.

Functional Analysis: In a recently completed work, Very Non-constrained (V.N.) subspaces of Banach spaces as a generalization of the concept of nicely smooth Banach spaces was defined. Many properties of nicely smooth spaces as special cases of results were recaptured in this broader set-up. In the process, a purely algebraic way of dealing with nicely smooth spaces was developed in sharp contrast to the topololgical tools in the original treatment. Just as nicely smooth spaces have the Unique Extension Property, a VN-subspace of X satisfies a natural analogue – the unique ideal property in X. Some stability results were also proved. Banach spaces that admit weighted Chebshev centres for finite sets were studied by L. Vesely and subsequently the notion of a central subspace of a Banach space was defined by others and it was shown that the so-called L^1-preduals have this property. As a part of work in progress extending the notion of central subspaces, relative intersection properties for a subspace Y of a Banach space X with the centres of the balls coming from a given family of subsets of Y was defined. Some extensions and improvement upon some of the earlier results in this general set-up were also obtained. As before, special cases when we consider the family of all finite, or more interestingly, compact subsets lead to characterizations of L_1-preduals.The special case when the family is that of all subsets gives rise to a notion apparently weaker than 1-complemented subspaces. It is still an open question whether the two notions are equivalent, even in the case of X in X^{**}, which was called the Finite Infinite Intersection Property ($IP_{f,\infty}$). Some sufficient conditions for the two to be equivalent were also obtained improving on earlier results..

New results were obtained on Semi-graphs and cycle stochastic graphs.

Theoretical Computer Science: Work continued in the area of approximability of hard combinatorial optimization problems related to linear ordering problems. Some interesting results have been obtained, which provide some evidences to support the conjecture that MIN-LOP (and related problems such as MIN-QAPCS, a restricted version of quadratic assignment problem, MIN-W-FAS, etc.) are not in APX, if $P \neq NP$. These include: (1) a result establishing a connection between coordinates of linear ordering polytope and the existence of a constant-factor approximate Solution of MIN-LOP, (2) a result stating the non-existence of a polynomial-time $(1-\varepsilon)\log n$ - approximate algorithm, for any $\varepsilon > 0$, for MIN-Subset-FAS, a generalization of MIN-FAS, unless NP $\subset$ DTIME ($n^{\log\log n}$), and (3) A result stating that MIN-W-K-FAS, a generalization of MIN-LOP, is NPO-Complete.

In Harmonic Analysis research was carried out in Wiener Tauberian Theorem on Heisenberg motion group, Helgason Fourier transform in L^1 and L^p spaces, Multipliers in SL (2, R) and Band-limited wavelets.

Some useful criteria for finite generation of noetherian subalgebras of polynomial algebras in one variable have been obtained.

Some faculty members of the unit continued the study of social networks from combinatorial and statistical perspectives in collaboration with Sociological Research Unit.

Projects Undertaken

Statistics in Ecology

The objective of the project is to analyze the available data on bird-watching to estimate the abundance of species of birds. There is no satisfactory method for doing this estimation based on bird-watching data. For a set of data consisting of counts of birds at a number of points made by an observer along a pre-specified path in a region, a statistical model was set up and a hierarchical Bayesian method of analyzing the data proposed. For the available data, however, a Fourier series model was found to be more appropriate. Finally a variety of possible models for the data were considered from which the "best" model was selected using the Bayesian Information Criterion.

Analysis of fMRI data and Human Brain Mapping.

Functional magnetic resonance imaging (fMRI) has been useful in brain research and associated diagnostic problems. The topic Human Brain Mapping deals with the problem of finding regions of human brain where specific tasks are performed. The goal of the project is to develop methodologies for feature extraction from fMRI data and to correlate the features with clinical and normal brain function, with a view to, in particular, testing biophysical, cognitive, and medical hypotheses.

The project explores the following for developing tools of analysing fMRI data: (a) Bayesian image analysis, (b) wavelets, and (c) change-point techniques. Such tools are expected to (i) be useful in studying irregular or nonstationary features present in the data, (ii) be able to decide sudden change in fMRI time series, and (iii) use a *priori* knowledge for finding region(s) of activation.

Some progress has been made on the project. An algorithm of image registration was developed using trimmed least squares, followed by identification of activation region which is based on the use of wavelets. Presently attention is on both wavelet based methods and Bayesian methods, with more emphasis on Bayesian methods.

Stat-Math Unit, Delhi

Research Activities

Problems of matrix analysis related to numerical analysis were studied. Norms of higher order logarithmic derivatives of matrices were computed. New representations of the partial trace function (arising in mathematical physics, linear algebra and statistics) were obtained and used to get new proofs of some theorems on quantum entropy.

Investigation of combinatorial interpretation of the minors of matrices associated with a graph was continued. The minors of the fundamental cutset matrix and the fundamental circuit matrix of a graph were considered. Interpretation of their minors and of some related matrices was obtained. Some connections with the minors of the Laplacian matrix were established.

Generalised Jocher's Procedure for Recovery of Interblock Information: Condition for goodness of the procedure was examined in a manner analogous to that for the Yates-Rao procedure in Bhattacharya (Sankhya,1998) and the two procedures compared.

A Symmetric Vec Operator with Application to MINQUE with Arbitrary Quardatic Norm: A symmetric vec operator was considered instead of vec operator used by Mitra (1971) to derive the same results more simply by least squares theory without constraints and to explain why it is necessary to impose the symmetry conditions in the derivation of the MINQUE only in the case of a non-euclidean norm.

Work continued on the problems of nonparametric and parametric statistical inference for a class of stochastic partial differential equations when the process is observable continuously over space and time or when the process is observable at discrete time points but continuously over space. Central limit theorem for U-statistics for associated sequences and extension of Wilcoxon type tests for associated sequences were studied.

Hajek-Renyi type inequality for associated sequences, Whittle type inequality for Banach space valued martingales and Whittle type inequality for demimartingales were derived. An Esseen-type inequality for the difference of two multivariate density functions was proved. A new concept of negative demimartingale generalising negatively associated sequences was introduced and a down crossing inequality for negative demimartingales was obtained.

Work was done in the area of stochastic orders as applied to order statistics, spacings and linear combinations of order statistics of nonhomogeneous observations in collaboration with B. Khaledi and Moshe Shaked. Members have also been interested in the area of competing risks and inference under order restrictions. Work on testing for the equality of competing risks was done jointly with K.F. Lam and Paul Yip of the Hongkong University. The problem of comparing the cause specific hazard rates of two discrete cause specific hazard rates under the constraint that they are ordered was studied with Barmi. The same problem, but with continous type data, has been studied jointly with El Barmi, Hari Mukherjee and Frank Samaniego. In collaboration with Professors Spiggichino and Basan work has been in progress on stochastic orders for multivariate distributions.

Stat-Math Unit, Bangalore

Research Activities

A major breakthrough in the theory of optimality of designs was made. For the first time, an infinite series of linked block designs were shown to have strong optimality properties (w.r.t. all convex decreasing criteria) in the unrestricted class.

Majorisation technique is now proved to be a very useful tool in the search for optimal designs. With the help of this technique the following optimality results were proved: General optimality of an infinite series and A-optimality of a number of infinite series of linked block designs in the general class, A-optimality of a large class of group divisible designs and the complements of partial geometric designs in the binary class. Further, the proofs of a number of existing results have been simplified to a large extent by using majorisation technique. Fractional factorial designs with small number of levels for each factor on a nested row-column set up have been considered. Universally optimal and specific optimal designs have been obtained.

An infinite series of adjusted orthogonal and E-optimal row-column designs has been constructed.

The minimum weight of the code of the incidence system of s-flats versus t-flats in projective spaces, and non-trivial bounds on the minimum weight of the dual codes were determined.

An exciting combinatorial approach to the four-dimensional smooth Poincare conjecture was found. Specifically, it was shown that if a six-dimensional twelve-vertex complementary pseudo-manifold is to exist then a negative resolution of this famous conjecture will follow.

All the homogeneous weighted shifts were classified.

Working on the structure of congruence kernels in rank 1 algebraic groups over nonarchimedean local fields, it was shown that, under some mild hypotheses, the congruence kernel has a quotient isomorphic to the free profinite group of countably infinite rank.

Working on central extensions of p-adic division algebras, a method of Prasad and Raghunathan to study p^2-torsion in the group of central extensions of $SL(1,D)$ for a p-adic division algebra D was explored. After indicating how to study p^2-torsion in general, the computation in a special case for $p=3$ was carried out and the existence of 9-torsion in the group of central extensions of a quaternionic division algebra over a p-adic field was shown to be equivalent to the existence of a primitive 9-th root of unity in the p-adic field.

Ergodic amenable action of algebraic groups over a local field of characteristic zero was shown to be induced by an amenable subgroup. This result generalizes a result of R. J. Zimmer which says that ergodic amenable actions of connected locally compact groups are induced by amenable subgroups.

It was proved that motion groups of totally disconnected nilpotent groups and certain class of p-adic algebraic groups which includes groups whose solvable radical is type R and general linear affine groups are identity excluding, that is on these groups unitary representation and weak mixing problems have affirmative answer. Algebraic groups (over a local field of characteristic zero) whose solvable radical is not type R and the action of a semisimple Levy subgroup on the unipotent radical is not type R are shown to be not identity excluding. Using Mackey theorem it was shown that on split solvable algebraic groups, the strong convergence of averages of unitary representation holds, that is unitary representation problem and hence weak mixing problem has affirmative answer. It may be noted that these results show that split solvable algebraic group is identity excluding if and only if it is nilpotent but unitary representation problem has affirmative answer on split solvable algebraic groups.

A Bayesian local smoother was developed for the estimation of a smooth function with special local features. The regression function was modelled as the sum of a polynomial and a Gaussian random process as in classical splines. The problem was formulated as a general linear model and a hierarchical Bayesian approach was then used to study it. An important feature of the proposed approach is that different degrees of smoothness can be assumed for the regression function in different regions of the domain of the function but it is constrained to be continuous at the boundary points. The novelty of this approach is the implementation of this feature by modeling the continuity constraints in the prior covariance matrix. The main advantage here is that there is no need for the computationally intensive constrained minimization which is usually required. Instead, the resulting estimator is expressed as a ratio of two single-dimensional integrals. Additionally, the local fitting of the model provides additional structure to the covariance matrix of the data and hence leads to substantial computational efficiency.

Algebraic reflexivity of local surjective isometries has been studied for spaces of vector valued continuous functions. It was shown that for a uniformly convex space whose group of isometries is algebraically reflexive and for a metrizable compact space, the group of isometries of the space of vector-valued continuous functions is again algebraically reflexive. Weak*-extreme points of the unit ball of a Banach space have been investigated. It was shown that for any function algebra A and for any Banach space E that has the extreme point intersection property for the injective tensor product of A and E, every weak*-extreme point of the unit ball is a strongly extreme point. An example of a Banach space having a weak*-extreme point in the unit ball that continues to be a weak*-extreme point of the unit ball of all the biduals of even order but is not a strongly extreme point was given settling a long standing problem in this area.

Results have been obtained on the existence and uniqueness of an equation in $+^1$ arising via duality from the Ito formula for Brownian motion.

The infinite dimensional equation for Brownian Motion mentioned above is in the form of an evolution equation. The representation of the solutions of this equation as a mild solution was obtained. This leads to an explicit formula for the integrand in the martingale representation for a class of finite dimensional functionals on an arbitrary probability space.

A probabilistic representation of solutions to the heat equation for the Laplacian, for an arbitrary initial value Q in ρ', generating the well-known case when Q is assumed smooth, was obtained.

Feynman-Kac semigroups with reflecting boundary conditions were analysed using reflected Brownian motion in a Lipschitz domain, and a conditional gauge theorem proved.

Well-posedness of reflected backward stochastic differential equation in an orthant with oblique reflection was studied.

Continued work on harmonic analysis on symmetric spaces has yielded a paper entitled "The Helgason Fourier transform for symmetric spaces". Progress has been made on the inversion formula for the Helgason Fourier transform for general L^1-functions. (So far this has only been done for sufficiently rapidly decreasing functions.)

Study of questions arising naturally from Lefschetz's theorem has shown that embeddings of the blow-up of a projective space along a linear subspace answers some of these questions negatively.

Work on uncertainty principles on Lie groups such as Hardy's theorem had yielded the following results : i) a general form of Hardy's theorem for semi-simple Lie groups and Euclidean motion groups, ii) Burling and Gelfand-Shilov theorems for semisimple Lie groups, Euclidean motion groups and rank one symmetric spaces, (iii) Hardy and Beurling theorems for step two nilpotent Lie groups and (iv) a Wiener Tauberian theorem for the Heisenberg motion group.

An analogue of the Tate Conjecture for divisors for normal singular projective varieties defined over number fields was proved.

In the topic of tensor product systems of C^*-Hilbert modules, completely positive definite kernels, morphisms of product systems and time ordered Fock modules were studied. The classification theory for these product systems was started. Main results obtained so far are: (i) a criterion for a set of units to generate a product system; (ii) a complete description of positive, projection, unitary morphisms of time ordered Fock modules; (iii) identification of product systems of dilations of CP semigroups with bounded generators as time ordered Fock modules.

The problem of obtaining minimal dilations of operator cocycles of E_0-semigroups of type I factors was considered. The main result here is that the minimal isometric dilation of cocycles always exists and is unique in a certain sense. Results analogous to Sarason's characterization that subspaces to which compressions of semigroups are again semigroups are semi-invariant subspaces, in the context of cocycles and quantum dynamical semigroups were obtained.

Dilations of commuting tuples of operators have been studied. A notion called 'maximal commuting piece' for tuples of Hilbert space operators has been introduced. 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 and hence it is a noncommuting tuple. There is also a commuting dilation related with a standard commuting tuple on Boson Fock space. It is shown that this commuting dilation is the maximal commuting piece of the minimal isometric dilation. This result is used to classify all representations of Cuntz algebra O_n coming from dilations of commuting tuples.

Also considered are type III product systems of Hilbert spaces. Examples of exotic product systems of this kind were obtained by B. Tsirelson using probability theory. It is seen that these may also be obtained through operator theory using Shale's theorem.

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.

Applied Statistics Unit

Scientists of the Applied Statistics Unit (ASU) are involved in various teaching, training, research and development activities. ASU is fully responsible for conducting the short-term course "Intensive Course on Programming and Application of Electronic Computers". This unit also regularly conducts teaching/training programmes like winter/summer schools and workshops. 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. Currently, there are collaborative on-going projects with the Theoretical Statistics and Mathematics Division, the Social Sciences Division and the Computer and Communication Sciences Division.

Research Activities

Sample Surveys

Some empirical exercise using Economic Census data was done to show that adaptive sampling through formation of networks is suitable for producing serviceable estimators for total numbers of people with specified

features that are widely scattered in various localities. On studying national remotely sensed data, adaptive sampling was also observed to be useful in estimating sparsely located scarce objects like wetlands enriched with minerals.

In the context of randomized responses (RR) techniques results were developed to yield estimates of people with sensitive characteristic when samples are drawn according to complex designs, with special reference to replicated RR techniques. Both maximum likelihood and method of moment estimators were employed yielding mean square error estimators in this context. Efficacy of IPNS technique was demonstrated in the RR surveys, with reference to unrelated question models in particular.

In the context of multi-stage sampling in unbiased estimation of the mean square errors (MSE), standard results start with the MSE formulae as quadratic forms suggesting complications in case a standard MSE is in a different form. Appealing to commutativity in expectation operators in the *initial* and *later* stages of sampling, *simplified* procedures were developed with efficacies demonstrated in respect of empirical data.

Hájek's (1958) approach was extended to provide unbiased uniformly non-negative estimators for MSE of estimators for totals when JNK Rao's (1979) 'constraints' are relaxed, extending the application to generalized regression (GREG) estimators, multistage sampling and RR surveys.

Taking interest in the methods followed by various State Governments and also by the Government of India in estimating (i) areas under principal seasonal crops, (ii) their yield rates and (iii) amounts of their yields, certain corrective measures had been recommended previously. Further modifications on the earlier procedures were provided during the year under review. For the CSO Industrial Wing, Government of India, certain revisions in the sampling designs have been recommended and found acceptable to them and are being implemented. Further work was done to cover GREG, empirical Bayes (EB) and Kalman filtering.

Using Economic Census data it was demonstrated how in stratified two-stage sampling, improved estimation is possible in estimating the *first-stage unit level* values employing the GREG and EB methods essentially by appealing to the Small Area Estimation principle of borrowing strength, and modifying the initial estimators earlier employed.

Design of Experiments, Combinatorial Methods and Their Applications

Cross-over designs were studied for obtaining combined intra-inter subject estimates and optimal designs were obtained under the corresponding model. Cross-over designs of small size were obtained which are efficient for direct effects and optimal for carry-over effects.

Some optimal designs for scheduling multiple examination times were developed for simple illness-death model with possible application in cancer screening studies and industrial monitoring.

The allocation problem and related inferences were studied for clinical trials. The details are given in the next section.

Biostatistics

A randomized longitudinal play-the-winner (RLPW) rule was developed for allocation of rheumatoid arthritis patients in one of two competing treatment groups, including pulsed electro-magnetic field (PEMF) therapy. The rule takes into account some ethical considerations. Some inference procedures were worked out with application in PEMF study with rheumatoid arthritis patients.

Some nonparametric group sequential designs and related test procedures were studied with reference to potential application in clinical trials. Some of the designs are adaptive in nature. Some group sequential designs were studied for survival data also. Some adaptive designs for phase III clinical trials were studied for continuous treatment responses.

A comparative study of univariate versus bivariate categorical data was carried out with reference to some real data from an ophthalmologic study.

Some new probability models were introduced for bivariate binomial distribution and a detailed study was carried out for the distribution of log-odds ratio in the dependent set up.

Reliability, Life Testing and Survival Analysis

Availability of a maintained system with s spares and with r prefect repair facilities was calculated.

Development of a method of estimating cause-specific hazard rates in a competing risk problem with missing failure types was completed. This method overcomes the problem of estimability associated with a conventional EM algorithm-based method, by means of additional assumptions on the missing mechanism.

A goodness-of-fit test for log-concave distributions in the context of lifetime data was improved. The new test is consistent. No other consistent test for this problem is available in the literature.

Cryptology

Research on proper choice of connection polynomials of linear feedback shift register (LFSR) for use in stream ciphers was carried out. Some necessary properties have been identified and methods to construct polynomials with such properties were developed. New classes of resilient S-boxes and Boolean functions were identified. A new model of stream ciphers was developed. Cellular automata plays a crucial role in the actual realisation of this model.

A parallelizable design principle for cryptographic hash functions was designed. This principle was used to design a new hash function which is provably as secure as the industry standard SHA but is 12-18 % faster in computing the message digest. New and efficient parallel methods for construction of universal one-way hash functions were developed. These have potential applications in speeding up computation of message digest.

International collaboration was established with several leading research institutes like Lund University, Sweden and University of Waterloo, Canada.

Inference

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 model via likelihood based cross validation technique. An application of this method was considered with data from Seattle, USA.

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.

Some review works were done on model selection and nonsubjective Bayesian analysis providing new insights based on current research. A unified derivation of the well-known methods of nonsubjective Bayesian model selection was presented and it was shown that in some qualitative and conceptual sense, these methods are close to each other.

Linear Models and Multivariate Analysis

Results on updates in the general linear model were applied to various problems such as missing plot substitution and best linear prediction in state space models, thus expanding the scope of existing results. The latter work generalizes the Kalman filter to the case of correlated error and singular error dispersion matrix. An 'impossibility theorem' in the context of equivalence of least squares and best linear unbiased estimators was proved. Asymptotic normality of the best linear unbiased estimator in a singular linear model under weak conditions was established.

Asymptotic expansion of the distribution of linear discriminant function, based on unmatched training samples from correlated populations was derived.

Other areas

Some methods of constructing multivariate ordinal categorical random variables with a desired pattern of association were examined.

A permanental inequality was proved, thus settling a conjecture that was posed in 1993.

Subsequent to the Doordarshan project (described under 'Projects Undertaken'), the inconsistency and inaccuracy of the opinion and exit polls published at the time of the West Bengal assembly elections were analyzed. A statistical analysis of the election results was also carried out.

Projects Undertaken

A. Internally Funded Projects

Analysis of SODAR Data

In this project, pattern recognition techniques were used for identifying two of the typical categories of patterns that are detected in acoustic echo sounding (or sodar) data, namely, thermal plumes and inversion. The data was treated as an image over time, and the boundary between the turbulent and non-turbulent regions, as observed in the data, was estimated using statistical change-point detection techniques. This boundary was treated as a time series, and three different sets of features were proposed on the basis of the Fourier transform of this time series. The results obtained with some standard classifiers, like the Bayes and the k-nearest neighbour for distinguishing between the two classes of patterns, were encouraging.

Winter School on GIS

The Unit conducted a School on Geographical Information Systems (GIS) during 8-18 January 2002 at Kolkata. The School was for sponsored candidates only. Out of the 80 nominations received, 31 were selected, and 24 participated. Of the 24 participants from 12 different States, 14 were faculty from the Universities and collages, and the remaining 10 were officers and researchers from Central and State Government departments and organizations. Resource persons included 10 internal and one guest faculty from IIT Bombay.

Topics covered in the School included principles of GIS, image storage and retrieval, scanning and digitization of maps, and formation of thematic maps. The program included hands-on learning sessions using the GIS package GRAM++. A 53+iv page 'Training Manual for GRAM++' was prepared for step-by-step learning.

North-East Training Programme

A training programme for officials of the government and public sector units from North Eastern part of India, on the use of personal computers in data processing was organised by the Unit during February 11 - March 8, 2002 at Kolkata. From a large number of sponsored applicants, 23 were selected for training. Theoretical and practical training was imparted by the members of the Unit and Computer and Statistical Services Centre. As part of the training the participants had to take up a supervised project related to their area of work. The project was evaluated. The course was well received. Similar training programmes are planned for the future.

B. Externally Funded Projects

Analysis of West Bengal Assembly Elections Data

At the request of Doordarshan Kendra, Kolkata, ISI undertook a brief project for analysis of the results of the assembly elections conducted in West Bengal on 10th May, 2001. Data on past elections, downloaded from

the website of the Election Commission of India, were used to build a prediction model. The task was to project eventual seat share of various political formations on the basis of partial counting results on the day of counting of votes, and to compare the outcome of the 2001 assembly election with that of earlier elections. Members of the project team participated in a day-long election analysis programme at the DD1 channel on 13th May (the day of counting), and succeeded in making a very accurate prediction of the seat share shortly after 10:00 a.m. The accuracy of this prediction itself became a news item in another television channel.

Developing Audit Sampling Tools

This project was taken up at the request of the Department of Finance, Govt. of West Bengal. Phase I of the project, which covered the health sector, had been completed earlier. Phase II covers the (i) Public Works Dept (PWD), (ii) Public Health Engineering Department and (iii) Irrigation and Water Works Department with the reference period 1.4.2000-31.3.2001. The work done during the first year of the second phase was as follows. Out of a total of 383 relevant offices concerning the above, 79 offices were selected in the districts of Kolkata, Bardhaman, Bankura, Birbhum, Jalpaiguri, Malda and Midnapur for an actual survey utilizing information on the office-wise monetary allocations for the year 2000-2001 in sample-selection. Survey was completed in 20 offices and out of the targeted 32000 questionnaires to be canvassed, roughly 12000 were covered. Computerization of the data is in progress as per prior arrangement.

A Fast Software Implementation of LFSR-based Cryptosystem

This project was funded by Indian Navy. A prototype private key cryptosystem based on stream cipher for fast communication was implemented. The actual system based on this prototype will be developed by the Indian Navy. The system has been named the *Royal Bengal Cipher*.

Design/Aid Tools for Synthesis of Boolean Functions

Boolean functions having good cryptanalytic properties were studied. A tool was prepared for enhancing the hardware design of a class of such Boolean functions. The project was funded by the Centre for Artificial Intelligence & Robotics (CAIR).

Connection Polynomials of LFSR-based Systems

Properties of connection polynomials that are of cryptanalytic importance were explored. Algorithms for constructing such polynomials were also designed. The project was funded by the Scientific Analysis Group of the Defense Research & Development Organization (DRDO).

Cryptanalysis of Complex LFSR-based Systems

Cryptanalysis of linear feedback shift register (LFSR)-based systems are to be studied when (i) the combining function has memory and (ii) the combining function is correlation immune. The project, funded by DRDO, began towards the end of the year 2001-02. Some studies on correlation immune functions were made.

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 supervision of the faculty members of this division. Research work carried out in these units is summarized below.

During the period 2001-2002, the faculty members of the Unit were engaged in research in various major areas of Computer Science including Parallel/Distributed Computing, VLSI computer-aided design and testing, Computational Geometry and Mobile Computing.

Mobile Computing

The rapidly expanding technology of wireless communication aims at making information accessible anywhere and at any time. Mobility and portability create an entire new class of applications combining personal computing and wireless communication. The challenging research issues investigated are as follows:

The notion of dynamic location areas, termed as grid for reducing the location update cost was introduced along with an efficient paging scheme at an enhanced power. Simulation results show an appreciable reduction in the total location management cost as a whole over the existing techniques.

Modeling of the mobility pattern of the mobile devices is an important part of the performance evaluation for various update schemes. A new realistic model for mobility was developed. Several location management schemes were evaluated under this mobility model.

The Static Channel Assignment Problem for hexagonal cellular networks with non-uniform demands from different cells was investigated. The problem is known to be NP-complete. The notion of a critical block that results in optimal assignment for all eight well known benchmark instances was introduced, thus out performing the existing techniques in terms of total bandwidth and computation time.

A novel deterministic broadcast protocol for an ad hoc network has been proposed which avoids recomputation of the transmission schedule, even when the topology of the network changes due to the mobility of the nodes. The proposed protocol is simple, easy to implement and needs shorter broadcast time than the existing ones.

Label Placement in Maps and Graphs

In Geographic Information System (GIS), automated label placement is an important problem dealing with positioning labels for area, line and point features on a 2D map. Two basic goals of a labeling algorithm are : a label should touch the site to which it belongs, and two labels should not overlap. Another important constraint is that the label of one feature should not obscure any other feature on the map.

Two major types of problems can be considered: (1) labeling as many sites as possible, and (2) finding the largest possible size of the label such that all the sites can be labeled in a non-overlapping and non-obscuring manner. The general versions of these problems including approximation algorithms with factor less than 2, are known to be NP-hard.

A special case of the point set labeling problem was considered, 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 given 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, which can be solved in $O(n\log n)$ time. 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.

Floor planning for Deep Submicron Integrated Circuits

The problem of floorplanning for dual voltage chips commonly used in deep submicron technology, 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.

A max flow-mincut based heuristic for balanced bi-partitioning under geometric constraints, has been designed. This method provides an additional advantage of incorporating look-ahead for the global routing phase of the floorplan. Implementation and experimentation with some benchmarks have also been carried out. A beta version of recursive bi-partitioning algorithm has been completed.

Test Response Compression for Embedded Cores/System-on-a-Chip (S-o-C)

A new technique for designing zero-aliasing space compactor for response compaction in combinational IP cores has been developed. It has been shown that the limitation imposed by an earlier logarithmic bound on the number of compactor outputs for zero-aliasing can be overcome, if the compactor is fed with the inputs of the core in addition to its outputs. This approach has a drastic effect on solving the aliasing problem. The compactor was designed for each of the ISCAS benchmark circuits, and the results reveal significant improvement over earlier methods. For scan-based sequential cores, a new technique has been developed to synthesize a zero-aliasing compactor based on a novel concept of distinguishing lines and characteristic function of the response matrix. The proposed compactor is applicable to any arbitrary sequential circuit, and provides single-output (maximum) compaction with zero (minimum) aliasing. This solves a long-standing open problem in compactor design: till date, it is 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.

Multi-Mesh Architectures

The Multi-Mesh network was originally introduced by this research group in ISI; it provides a better architecture over the usual 2D mesh or torus. The basic scheme of interconnecting the processors in a Multi-Mesh has been generalized to connect any number of nodes., i.e., it becomes incrementally extensible. It can be very effectively used in WDM (wave division multiplexed) optical networks because of its interesting feature of lower call blocking probability. Simulation studies have been made that support the theoretical claim. Studies are also in progress on efficient placement of processors of a Multi-Mesh on a 2D VLSI chip.

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 have been proposed which work for the unidirectional and bi-directional ring networks. These algorithms outperform the existing algorithms in terms of number of messages and time. Work is in progress for all Hamiltonian topologies.

Cache Conscious Algorithm Design

Performance of traditional algorithms is measured in terms of number of instruction executions. In modern machines, with the presence of cache memory, execution time can change with the cache-hit ratio. The simple Canny edge detector algorithm for redesign with the presence of cache taken into account was considered. It was found that the modified algorithm performs better in terms of cache-hit ratio. But an increase in the instruction count results in a marginal decrease in the actual execution time.

Star Coloring of Graphs

Among the several variations of constrained vertex coloring of graphs, a k-coloring of an unoriented graph is called *star coloring* if there do not exist two colors such that the subgraph induced by the vertices of those two color classes contains a path of length greater than 2. This kind of special coloring has been addressed for special classes of graphs such as 2D and n-dimensional grid, 2D and 3D torus; tight upper bounds for the star chromatic number for these classes have been established.

Facility Location

Various optimization problems which arise in the application areas of facility location, robot motion planning, defense application, etc., have been considered. Several online query answering problems were also

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. Currently work is in progress on efficiently characterizing 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.

Optical Interconnection Networks

Interconnection networks play an important role in parallel processing systems as well as in communication systems. The emerging technology of optical interconnection networks offers wide bandwidth and high speed to meet the increasing demand. Along with the advantages, the optical interconnection networks have their own challenges. All optical interconnection networks are yet to be commercialized. A class of hybrid optical multistage interconnection networks (MIN) were studied, where the optical signal passes through optical switches, but the setting of the switches is done electronically. Some elegant routing schemes were developed to route permutations with minimum number of stages in such a network. This is important because in hybrid networks, as the signal passes through the switches, it gets attenuated. Therefore, by minimizing the number of stages, the attenuation of the signal can be kept minimum. A new technique for combining two unique-path full-access MIN's to produce a re-arrangeable MIN that can route any arbitrary permutation in a single pass, has also been proposed.

Topological Routing in ULSI Chips

The primary objectives in interconnection for emerging technology such as deep submicron ULSI (Ultra Large-Scale Integration) chips, and MCMs (Multi-Chip Modules) are to reduce delay, crosstalk and number of layers. The motivation of topological routing is to solve the problem of global routing for a given netlist and placement of modules efficiently, without having the restriction of pre-defined shapes of routing regions. Typically, the nets are routed one by one; for each net, the shortest Steiner tree connecting all the terminals avoiding a set of obstacles is to be determined. The ordering of the nets plays a critical role in achieving 100% success in routing. Re-ordering of the existing routers emphasizes determining the shortest path at every stage.

An alternate graph search approach is to consider all the nets concurrently and connect the pins of all nets simultaneously. The obstacles are assumed to be arbitrary convex polygons. Although this may seem unusual for the state-of-the-art VLSI chip technology, this situation arises if one has to consider pre-routed special nets or groups of pre-placed and routed blocks which are obstacles for the router.

An algorithm for obtaining a sketch, i.e., a topological routing of nets having multiple terminals on one layer in a concurrent manner was devised. 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.

Built-in Self Test for Asynchronous Sequential Circuits

For asynchronous sequential circuits, BIST design technique has been addressed in collaboration with B.E. College (Deemed University) and Intel Corp., USA. The design is derived by software emulation using a min-max timing analysis based fault simulator, cellular automata based test pattern generator and response evaluator. It was tested on benchmarks as well as the asynchronous instruction length decoder of a microprocessor.

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.

Optimal partitioning, logic synthesis, placement and routing targeted for high performance FPGA realization have been addressed by the Unit in collaboration with IRISA, Rennes, France. In particular, an elegant solution for optimal partitioning of a static control iteration for mapping onto an FPGA chip through

system bus, has been given. Discovery of certain salient properties of decomposable Boolean functions has led to an efficient heuristic for logic decomposition and minimization relevant to technology mapping onto FPGAs. A promising FPGA placement approach with Tabu search has been designed.

On-Chip Implementation for Content-based Image retrieval

With the advent of massive transactions across the internet, search and retrieval of an image from a globally distributed and enormously large database, has emerged as a very important technological goal. Researchers of this Unit have been exploring various new techniques for content based image retrieval (CBIR) using novel ideas of image characterization, computational geometry, and data mining. Future generations of personal and mobile computers are likely to provide on-chip implementation of CBIR to accelerate image searching and retrieval. This research also focuses on designing VLSI chips to accomplish feature extraction for CBIR on-line. 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 . The following patent applications were filed with US Patent Office: (i) Computing the Euler Number of a Binary Image; (ii) Developing an Euler Vector for Images; (iii) Image Retrieval using Distance Measure; (iv) Method and Apparatus for Providing a Binary Fingerprint Image; (v) Method and Apparatus to Reduce False Minutiae in a Binary Fingerprint Image; (vi) Architecture for Processing Fingerprint Images, (vii) Method of compressing an image; (viii) A method for block based digital watermarking.

Computer Vision and Pattern Recognition Unit

Research Activities

The main topics of research in this unit are given below.

Document Analysis

Work on improving the Optical Character Recognition (OCR) system developed by the Unit for printed Bangla and Hindi texts continued. A prototype system for the OCR of Assamese and Oriya script has also been implemented. Preliminary work on recognition of hand-written text, particularly numerals has been completed. Further, on-line Bangla numeral recognition from tablet and stylus input has been done. A prototype for the detection and segmentation of touching numerals has been developed as well. Other aspects of document analysis, such as automatic separation of scripts in a multilingual document, automatic skew correction, identification of type styles (bold, italic, etc.), recognition and segmentation of mathematical expressions, analysis of table-form documents, and searching for keywords in a document image, are also being studied. Investigations into document data compression have also been initiated.

Biomedical Image Analysis

Work commenced on the analysis of functional Magnetic Resonance Imaging (fMRI) data for the study of the human brain. A novel yet simple technique for the registration of such images was formulated. Both wavelet-based as well as statistical tools for the analysis and modeling of such data are been developed. Related important aspects such as the presence of physiological and electrical noise are being investigated in detail.

Handwritten Character Recognition

Work on recognition of the handwritten Bangla alphabet has been started recently. A hybrid system based on both supervised and unsupervised neural network models has been developed which can deliver around 93% recognition accuracy on a moderately large database of handwritten Bangla numerals. In addition, a system that can extract information from handwritten form-based documents of a given layout has been developed.

Neural Networks and Genetic Algorithms

The use of self-organizing neural network models for solving problems in Computational Geometry, such as finding the smallest hypersphere enclosing a given set of points in arbitrary dimensions, and the k-centre problem has been investigated. The application of such models to document analysis tasks is planned. The problem of premature convergence of genetic algorithms has been under investigation . A new genetic algorithm-

based approach has been formulated for self-adaptation of learning rates of the backpropagation algorithm. In this implementation of GA, an adaptive mutation rate which can provide better convergence performance was considered.

Natural Language Processing

Work continued on the linguistic analysis of Bangla noun, adjective, adverb, and pronoun word forms, as well as compound, reduplicated, and onomatopoeic words. Some preliminary work was completed on stylo-statistical analysis of Bangla sentences. A multi-lingual dictionary is being constructed for some of the major Indian languages. A dictionary that allows phonetic searching has been constructed, and has been incorporated into the sophisticated spell-checker for Bangla. Work started on machine translation of weather reports between Bangla and Hindi languages. An Indian language Braille processing system has also been developed. Technology transfer of spell-checker has been completed.

Speech and Signal Processing

An improved pitch detection program that uses state phase analysis has been implemented. A study of the intonational and prosodic patterns in Bangla speech was also initiated. The results of this study can be applied to detection of word boundaries during continuous, automatic and speaker-independent speech recognition and the proper modulation of machine generated speech (as in the *dictionary for blind* developed by the Unit). Some speech data has been collected for this purpose.

Methodology Development

In addition to applied research in the various areas mentioned above, the Unit is involved in the development of theoretical methods and algorithms related to fuzzy sets (definition of a fuzzy correlation measure), dot pattern analysis (shape estimation and border analysis of dot patterns), data clustering (especially for noisy data), etc.

Information Retrieval

Work on a language-independent, n-gram based method for language identification and text categorization has been started. Brill's part-of-speech tagger is being adapted for Bangla texts. This will be used within a question-answering system. The task of metasearching is being studied. Soft computing techniques for information retrieval are also being investigated.

Technology Transfers

The OCR technology developed by the Unit for Bangla and Devnagari scripts has been transferred to C-DAC for commercialization. MoUs are being negotiated with ER&DCI, Noida, and IIT, Guwahati, for the transfer of the Devnagari and Assamese OCR technologies.

Electronics and Communication Sciences Unit

Research Activities

The broad areas of research activities carried out during the period April 2001 to March 2002 are: (a) Theoretical and experimental investigations in computer vision, biomedical imaging and image analysis, (b) Development of theory and applications of computational intelligence tools in pattern recognition, (c) Remote sensing and data analysis in atmospheric science and wave propagation.

Highlights of the major research works, their novelty, important results and utility:

Theoretical and Experimental Investigations in Computer Vision, Biomedical Imaging and Image Analysis

Image Processing and Analysis:

A fast algorithm for active contour (called snake) detection has been developed incorporating the multi-resolution approach. A new image compression algorithm based on vector quantization technique was

developed. A fast algorithm for detection of skew of document page image was developed and compared with existing methods in terms of time requirement as well as accuracy. An empirical measure of performance of document image segmentation algorithm was proposed. This measure is based on a graph-like model that represents the segmented output in the most compact way satisfying the desired objective. Performance of previously developed document image segmentation algorithm was measured and reported.

Morphological Methodologies for Image Processing

A multi-scale morphological algorithm for fusion of grayscale images obtained from various sensors was developed. The algorithm is implemented using a scale-ordered data representation, namely 'Morphological Tower'. This tower was also used for implementing a multi-scale noise removal algorithm and for segmenting images containing objects of varying size and contrast. The algorithms were tested on a large set of images and evaluated using objective measure for comparative study.

Information Retrieval from Image

Work on content-based image retrieval based on shape and color features continued. The research mainly focused on development of image segmentation technique for content-based image retrieval. An agglomerative image clustering algorithm was developed for segmenting color images. The approach does not need any prior knowledge of number of clusters present in the image. The perceptually relevant segments of a definite size are detected based on boundary strength and region homogeneity parameters. An image watermarking technique that can authenticate a buyer was also developed. The strength of the algorithm is in its robustness against a set of spatial and frequency domain attacks. It was shown that the buyer specific key is still secure even when the algorithm is made public.

Development of Theories and Applications of Computational Intelligence Tools in Pattern Recognition

A novel scheme was developed for designing vector quantizer (VQ) for image compression. Code vectors are first generated using self organizing feature map (SOFM) algorithm. Then a cubic surface fitting method is used for better perceptual fidelity of the reconstructed images. The mean-removed vectors are used for better performance of the VQ. The performance of the VQ designed with a universal codebook was studied. Schemes for Huffman coding of the indices generated by the encoder as well as the difference coded mean values were developed. Methodologies were developed for selection of a small but adequate set of fuzzy rules for designing controllers. Concepts of certainty and utility of rules were introduced and used to explore the data for extraction of rules.

A novel connectionist system for feature selection was developed. The method is completely unsupervised and it attempts to select features preserving the inter-point distances and thereby can select features that can maintain a very good performance level both for clustering and classification applications.

A multi-layer dynamic neural network model was proposed for the computation of the convex-hull of a planar set of points. The network receives one point at a time and evolves to adapt itself to the hull-vertices of the convex-hull. Different subnetworks are used for computation of angles, finding the winner and for making decision whether the new point is a hull point of the augmented data set. One of the subnetworks adjusts its weights and self-organizes by labeling the hull-processors in an orderly fashion so that the final convex-hull is obtained from this layer. Time complexity of the proposed model was analyzed and compared with that of existing models of similar nature. Moreover, an O(1) Rank Net architecture was proposed for the computation of the maximum.

Self-organizing maps were used for generation of prototypes which were in turn used to extract a set of fuzzy rules. Each rule represents a region of the feature space called the context of the rule. Rules are then tuned with respect to their context and also the context is tuned through tunable parameters of a soft-min operator. The effect of context-sensitive inferencing on classification was studied. The effect of different inferencing schemes for different rules was also studied. The method was tested on several satellite images and the performance was found to be quite satisfactory.

Remote Sensing and Data Analysis in Atmospheric Science and Wave Propagation

Prediction of Atmospheric Data Using ANN

To capture the seasonality of atmospheric data, with a view to improving the prediction accuracy of the maximum and the minimum temperatures, a hybrid network was proposed that combines an SOFM and several multilayer perceptron networks (MLPs). This results in a hybrid network named SOFM-MLP with improved performance. It was also demonstrated that use of appropriate features such as temperature gradient can not only reduce the number of features drastically but also improve the prediction accuracy. These observations inspired the use of a feature selection MLP denoted by FSMLP (instead of MLP) which can select good feature on-line while learning the prediction tasks. The combined use of FSMLP and SOFM-MLP results in a network system that uses only very few inputs but can produce good prediction.

Investigation on Certain Dynamical Systems

Turbulent wind data have been collected from different heights of meteorological tower and for the investigation/characterization of such complex turbulent wind field, fractal and multi fractal techniques have been utilized. In the model based prediction of storm, monitoring of wind speeds in stormy seasons on high seas, favorable for cyclogenesis, is necessary and yet to be tested in real situation. The Unit developed a model on complexity of wind in Antarctica by analysing the self-similar behavior, information entropy and intermittence phenomena of wind pattern.

Ozone Layer Study

The Unit is developing a system that should be able to predict distribution of the ozone concentration over the globe based on the previous data. One module was developed so far in this direction, in order to obtain missing values of TOMS (Total Ozone Monitoring Spectrometer) record by using bilinear interpolation technique. Secondly, cross correlation between ground reaching ultra-violet radiation intensity and ozone value over a part of Antarctic region has been calculated and tabulated for further use in prediction model.

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 advanced technologies like fuzzy logic, artificial neural networks, genetic algorithms, fractals, wavelets and rough sets.

The investigations being done in MIU comprised 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

A clustering technique for determining the appropriate cluster centers has been developed. This has been extended to the case when the number of clusters is not specified *a priori*. A cluster validity index was

defined in this regard, the maximum value of which across a hierarchy of clusters indicates the correct partitioning of the data. Its superiority over some other validity indices has been demonstrated.

Image Analysis/Processing and Computer Vision

A new computationally efficient and robust blind image watermarking technique, in spatial domain, has been developed. In this technique different pixels of watermark symbol are first spread randomly using Pseudo Noise (PN) sequence (key) over a larger area (same as cover image), which is followed by their insertion in quasi-random position of the cover image using a second secret key. Spatial mask of suitable size is used to hide the watermark without perceptual degradation. Experimental results indicate that the proposed technique is resilient to common external attacks like mean & median filtering, lossy compression (JPEG), cropping and scaling.

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

A method for hue preserving enhancement of color images was proposed. Its superiority over the existing hue preserving enhancement methods was experimentally established.

Soft computing methodologies are used for extracting object regions from gray images. Object extraction was done using Hopfield type networks whose architectures are evolved by GAs and image ambiguity measures. Both graylevel ambiguity and spatial ambiguity measures were considered, in isolation and in combination, as fitness measuring criteria for GAs. For compact objects spatial ambiguity measures showed better performance than the grayness ambiguity measures; whereas for non-compact objects the reverse was noticed.

Content Based Image Retrieval (CBIR) is another research area of MIU. Here attempts to develop techniques for robust and invariant characterization of both two tone and gray tone images for CBIR application have been made. Efficient techniques for computing geometrical properties, of two and multi tone images like Euler number, Euler vector, higher order moments and compactness have been developed and their performance was tested on different kinds of database like trademark database and picture databases.

Data Mining and Knowledge Discovery

For the purpose of developing scalable algorithms for data mining the following two approaches were studied : (i) multiscale condensation of data sets and their underlying distribution, mathematical formulation of the data condensation problem and its convergence properties; and (ii) sequential and active learning to reduce computational complexity. Learning algorithms having low sample complexity like the support vector machine are also used.

An algorithm for multiscale data condensation was developed and its superiority over existing data condensation techniques has been conclusively demonstrated with the help of statistical testing methodology. A new feature similarity measure, namely "maximum information compression index" has been defined using the principal components of a pair of features. The utility of the proposed feature similarity measure has been demonstrated on several large data sets for the feature selection problem. An incremental learning algorithm for finding support vectors has also been proposed and its utility has been successfully demonstrated.

GAs are being 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, comprehensibility, interestingness etc. Genetic operators were also modified in this regard. Investigations are going on to compare the proposed techniques with existing algorithms.

Genetic Algorithms (GAs)

Multi-parent recombination is becoming popular in genetic algorithms due to some of its advantages. One such model is called univariate *marginal distribution algorithm* (UMDA) where allele-wise probability distribution of genes is used to generate a new offspring. This technique was applied to non-stationary function

optimization, and it was observed that such an algorithm can trace the change in environments much faster than the conventional GAs.

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

Fractals and Wavelets

A new multi-class texture segmentation technique using multi-scale wavelet frame analysis has been developed. Here a texture is decomposed into a set of band-pass channel by circularly symmetric wavelet filter. This decomposition extracts the edge magnitude at different scales. The texture is characterized by local energy over small overlapping windows around each pixel at different scales. The method is found to be invariant under rotation, translation and gray scale transformation of an image. It is also tolerant to Gaussian random noise of good degree. A method of extracting multi-scale wavelet features was developed. These features were then evaluated with respect to their importance by neuro-fuzzy feature evaluation method. The method was applied for segmentation of various multiclass textured and remotely sensed images.

Neuro-Fuzzy Computing

Various applications of neuro-fuzzy systems for classification and rule generation have been demonstrated in the past decade. Recently an application of such a system has been made in the radio communication domain for studying the different modes of radio wave propagation. The suggested model enables the speculation of radio wave signal situations at the receiver site and is useful to the researchers working in the area of remote sensing, atmospheric science and various other related fields.

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 have been developed in neuro-fuzzy framework. For these purposes, fuzzy indices were defined in terms of weighing 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 the existing case selection methods, the cases here were cluster granules, and not sample points. Moreover, each case involved 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 multispectral satellite images was also 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 has also been developed incorporating domain knowledge into the network parameters through rough set rules.

International Collaboration

The Unit has many collaborative projects with foreign universities. These include (i) a collaborative project with College of Engineering, Osaka Prefecture University, Osaka, Japan, coordinated by MONBUSHO (ministry); (ii) an INDO-POLISH collaborative project titled "Reasoning under uncertainty about complex objects/rough set theory and fuzzy set theory", with Institute of Mathematics, University of Warsaw, Poland, coordinated by the Dept. of Science & Technology (DST), India and the Polish State Committee for Scientific Research (KBN), Poland; (iii) INDO-CHINA project titled "Study Development of Intelligent Virtual Environment in Soft Computing Paradigm", with the Zhejiang University, China, coordinated by the Ministry of Science & Technology of the People's Republic of China and the Department of Science & Technology (DST), India; (iv) a collaborative project titled "Adaptation Guided Retrieval of Text Based Cases : A Neuro-fuzzy Approach", with the Dept. of Computing, Hong Kong Polytechnic University, Hong Kong, coordinated by the Research Grant Council, Hong Kong; (v) a collaborative project titled "Web Mining", with the INSEAD, France, (vi) a collaborative project titled "Data Mining using Soft Computing Techniques" with the Dept. of Computer Science and Engineering, La Trobe University, Australia, coordinated by the Australian Research Council, Australia.

Physics and Earth Science Division

The division comprises Geological Studies Unit and Physics and Applied Mathematics Unit. Faculty members of the division are engaged in teaching and training in B. Stat.(Hons.), M.Tech.(CS) and M. Tech.(QROR) programmes, besides their research and project work. Research carried out in these units is described below.

Geological Studies Unit

The Geological Studies Unit pursued its activity of geological research primarily in two regions - Proterozoic cratonic basins of South India and Palaeozoic – Mesozoic Gondwana basin of the Satpura region in central India. The unit also continued to provide support to a programme on Colloid, Surface and Environmental Science.

Research Activities

Proterozoic Geology

Proterozoic Intracratonic Basins

Aspects of stratigraphy, sedimentation and deformation in the Pranhita-Godavari Valley, Chattisgarh basin and Cuddapah basin were covered in the research programme on the geology of Proterozoic intracratonic basins. The results were integrated to constrain basin history. The bearing of the geology of the Indian Proterozoic basins on the assembly and break-up of Proterozoic supercontinents has been emphasized.

The geological mapping in the Pranhita-Godavari (PG) Valley has been continued with a view to stratigraphic basin analysis. Three megasequences have been identified, considered as three synrift-postrift sequences, i.e., the Mesoproterozoic Pakhal sequence, the Meso – Neoproterozoic Penganga sequence, and late Neoproterozoic Sullavai sequence. It has been inferred that the PG Valley, Chattisgarh basin and Cuddapah basin, three major Purana basins in the South Indian craton, were initiated as intracratonic rifts along three major linear weak zones of Archaean – early Palaeoproterozoic age. Origin of the basins has been related to fragmentation of Proterozoic supercontinents. The age of sedimentation in the eastern Chattisgarh basin has been determined by radiometric dating of zircon separated from a welded rhyolitic tuff horizon. Mapping has been initiated to determine the exact stratigraphic position of the welded tuff in the sequence. The welded tuff points

to an episode of rifting which appears to be related to fragmentation of Rodinia, the Meso – Neoproterozoic supercontinent.

A major fan delta complex has been identified at the base of the Chattisgarh sequence. The occurrence of the fan delta complex corroborates rifting of the craton leading to the formation of the Chattisgarh basin. Facies analysis of shallow water, mixed carbonate – siliciclastic deposits and pelagic limestones in the Chattisgarh basin has been taken up to reconstruct the Neoproterozoic sea level curve.

Detailed sedimentological reconstruction including recognition of aeolian strata, from early Proterozoic deformed volcano-sedimentary successions from India is rare. The 2.1 Ga-old Karutola Formation, part of such volcano-sedimentary pile in the Dongargarh Supergroup, central India has been investigated. A spectrum of sub-tidal, intertidal, shoreface-foreshore and tidal flat deposits has been documented from Karutola Formation. A manuscript is in its final stage of preparation.

Two contrasting fluvial systems are well developed within the Sullavai Group north of Godavari River and can be co-related in all their physical aspects to similar units recognized further south. Contrasting lithology, facies, architecture and paleocurrent patterns in these two units indicate dissimilar climatic and tectonic regime under which they formed.

A collaborative programme on palaeomagnetic studies has been initiated with the Rand Afrikaans University, South Africa to determine the position of the South Indian craton during the Neoproterozoic. Samples have been collected from deep water limestones of the PG Valley and the Chattisgarh basin.

Nallamalai Fold Belt

Early phases of contractional deformation in the Nallamalai fold belt (NFB) and thrust transport of the Nellore schist belt rocks over the NFB were shown to pre-date intrusion of granitic rocks at around 1600 Ma. Later contractional deformation overprinting the late Paleoproterozoic-early Mesoproterozoic structures as well as affecting the late Mesoproterozoic-Neoproterozoic Srisailam Quartzite and Kurnool Group were documented from the northern part of the NFB and western border of the NFB. The new analysis of the structures of the NFB is significant in relation to a compressional orogeny which might have occurred along a craton margin consisting of eastern India, the southern part of western Australia and adjoined parts of East Antarctica during the interval 1800-1500 Ma.

Northeastern part of the Palnad sub-basin has been remapped to evaluate the deformation history and kinematics within the Palnad nappe.

Eastern Ghats Belt

High temperature dehydration melting and decompression in a clock-wise P-T path have been described from granulite complex of Paderu in Andhra Pradesh. Archaean granulite facies metamorphism has been described from the so called Proterozoic belt of the Eastern Ghats. U-Pb isotopic evidence of polymetamorphism has been documented from the Eastern Ghats belt. Microstructural and quartz c-axis fabric evidence for high-temperature shear zone at the western margin of the Eastern Ghats belt had been revealed. Regional and mesoscopic structural evidence were shown to indicate reworking in the Eastern Ghats belt. A new thermotectonic model was developed for the convergent Eastern Ghats orogen, which considered decoupling of the thickening crust and thinning mantle lithosphere during convergence, and thereby explains synkinematic granulite in a homogeneously thickening crust without extraneous heat input. Different types of P-T-t path have been shown to depend only on the time-scale of orogeny -- both burial and exhumation time-scale.

Gondwana Geology

Vertebrate Palaeontology

Fossil exploration in the Triassic sediments of the Satpura Basin resulted in the recovery of a good number of reptilian fossils from the Denwa Formation, which is otherwise known to be rich in amphibian fossils only. In the eastern part of the Satpura Basin, ribs and limb bones of large dicynodont have been found; another

prospective fossil site with archosaurian fossil material has also been located at the central part of the basin. A new site of dinosaur eggs with hatcheries has been noted near Jabalpur.

The metoposaurid amphibians of India have been designated as a separate taxon named *Buettneria maleriensis*, a new combination.

A new Fourier descriptor based method has been developed to analyse the shapes of the skull outlines of some extinct amphibians. The two-dimensional Fourier approximations of the skull outline data preserve the shape information in detail. It also helps to correct the skull outlines which were actually deformed due to overburden pressure as the Fourier fits are based on bilaterally symmetric approximations. The Euclidean distances of points on the symmetrised Fourier fits from their respective centroids are plotted against the indices of the points. The local extrema of these curves indicate some special points, important for functional analysis and taxonomy.

Stratigraphy and Sedimentology

Mapping of the Talchir Formation has been extended up to the western margin of the Satpura basin. Field studies revealed that the Talchir and Barakar Formations represent a continuous succession recording gradual warming from glacial climatic condition. Marine bivalves and abundant ichnofossils have been discovered from the Talchir Formation. Evidence of tidal influence has been recognized in both the formations. Facies analysis of the Barakar Formation indicates a shallow marine, deltaic environment.

Clast-fabric analysis of Talchir diamictites has been supplemented by a theoretical model that explains that the fabric developed in shearing granular flows under the combined influence of flattening and simple shear.

Sandbox model experiments reveal that the Gondwana basins of peninsular India originated contemporaneously in response to a bulk horizontal extension of the crust and the kinematics of the Satpura basin was that of sinistral strike-slip movement along the basin bounding faults.

The contentious issue of differentiating the sand-dominated Motur Formation from the underlying Barakar Formation in the western part of the Satpura basin was finally settled during the last fieldwork. Presence of thin red mudstone beds – a signature of climatic inversion well documented in the eastern part of the basin, provides the key. Facies of the Motur Formation in the western part is broadly compatible with depositional model of sandy braided streams.

Three-dimensional geometry of the wave-reworked delta-mouth sandstone bodies from the Bijori Formation has been worked out. The architectural style of the sandbodies serves as a major tool for lacustrine interpretation of this unit, inferred as fluvial deposits by earlier workers.

The angular unconformity that had been recognized in earlier fieldwork, in the central part of the basin, between the Upper Triassic Denwa Formation and the Jurassic Bagra Formation has been shown by recent mapping to extend over the entire strike length of the basin. That this unconformity represents a major event of tectonic uplift has been suggested from the lithologic and sedimentologic contrast between the mud-dominated Denwa Formation and conglomerate-dominated Bagra Formation.

Existence of both braided and meandering river systems during deposition of the Denwa Formation has been suggested from observations on significant lateral as well as vertical variation in sedimentologic character. The distribution of vertisols within the succession indicates that there was a temporal increase in aridity that probably caused the river system to change from braided to meandering and finally transformed the Denwa alluvial plain to a sheet flood dominated one.

Dune scale trough cross-beds and other traction bedforms were identified within the muddy intervals of the Denwa succession. It has been suggested that a part of these units were deposited from traction as detrital mud-aggregates. The occurrence of palaeosols vs. detrital mud-aggregates was used as a criterion to differentiate between floodplain deposits and muddy channel-fills.

Contrary to the earlier notion of alluvial fan origin, it has been inferred that most of the conglomerates and pebbly sandstone bodies of the Bagra Formation are dominantly braid-channel deposits. The internal organization of associated pedogenically modified mud-rich units is similar to that of a floodplain deposit.

Surface and Colloid Science

Surface, Colloid and Environmental Sciences involve research on a thematic programme, *"Physicochemical Studies on Self-organising Systems with Special reference to Micelles and Microemulsions"* as model systems for the development, characterization and uses of new single and mixed microemulsion systems.

Formulation of a good number of rarely reported microemulsion/ reverse micellar systems stabilized by single and mixed surfactants using different types of oils (vegetable, hydrophilic and hydrocarbon), cosurfactants and polar solvents (aqueous and nonaqueous) has been developed. It has been established from phase studies that such systems with large monophasic microemulsion zone are capable of solubilizing active ingredients, which includes model drugs, pharmaceuticals and agrochemicals, etc. for convenient applications.

The roles of several types of alcohols and esters with different lipophilicities and solubilities (cosurfactants) in such formulations have been established. The stability and the area of monophasic microemulsion zone are found to be dependent on the charge type of the surfactants, their mixing ratios, type of additives (electrolytes, non-electrolytes), and on their concentrations and also on the temperature. The opposing effects were observed for electrolytes and non-electrolytes. The changes in volumes of different Winsor phases have been found to be dependent on the type of additives and their concentrations, temperature and on both of them. Temperature insensitive mixed microemulsion systems with large monophasic zone have been formulated, as they possess good prospect of application.

Bicontinuous microemulsions (Winsor III) have been prepared using single and mixed surfactants of different charge types at different oil and water proportions. Fish-tail diagram has been utilized to underline the minimum requirement of surfactants, cosurfactant and addition of other surfactant, and other aspects (e.g. temperature, presence of electrolytes and non-electrolytes, etc.) on the phase characteristics (Winsor I → Winsor IV) of these microemulsion systems.

Studies for characterizing the physicochemical behaviour of these microemulsion systems, specially structure, dynamics, thermodynamics and transport properties, etc. have been initiated.

Physics and Applied Mathematics Unit

Research Activities

Physics

Condensed Matter Physics

From the idea of the proximity of antiferromagnetism and superconductivity, a model for the pairing mechanism in high temperature superconductors through the Berry phase formalism has been suggested. This gives the evidence for the pairing mechanism to be of magnetic origin. Different phases associated with high temperature superconductivity from the renormalization group analysis have been studied.

The model has also been studied in the light of non-linear sigma model where the charge carrier appears as a soliton. When a topological theta term corresponding to the Berry phase arises in the action it is found that the theta term attributes spin, statistics and the fermion number to the soliton.

An extended and generalized stability analysis of the Fock Darwin spectrum was carried out for parabolic confinement of electron in 2-dimensions acted upon by an applied transverse magnetic field.

A semi-analytic approach was developed to model the basic phenomena exhibited by few electron systems like q-dot in this area of Condensed Matter Physics (Theoretical).

Classical Optics

Study on a problem in the area of classical optics, viz, understanding the Generalized Snell's law in the proper physical perspective, has been undertaken.

Foundations of Quantum Mechanics

Bell's inequality violations and the concept of non-locality raised a 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 creates new interest towards understanding the foundational problems of quantum mechanics.

Physics at Planck Scale

The discrete structure at Planck Scale and the continuum space-time pose new challenge to the physicist community. A 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 will have 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 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

Quantum teleportation process has been applied to send entanglement to two distant parties, using two equally entangled channels. The necessary conditions for sending entangled state have been studied and their connection with violation of Bell's inequalities has been revealed.

The discrimination among orthogonal entangled states for general bipartite system by local operation and classical communication is being studied. For 2 x 2 system, the problem has been solved using bound on distillable entanglement. The result has been extended to maximally entangled state for $d \times d$ system.

Quantum Field Theory

Various issues in Non-Commutative (NC) quantum field theory are being investigated. In the context of chiral anomaly in NC field theory, the existence of an extra term besides the expression derived by other workers has been shown. The extra term is crucial in showing consistency with the Seiberg-Witten map, which converts the NC anomaly to the celebrated Adler-Bell-Jackiw anomaly in ordinary space-time. The occurrence of non-commutativity in the Hamiltonian formalism has been sestablished rigorously exploiting the Nambu-Goto or Polyakov model for string moving in a background potential. Contrary to popular belief (that here the non-commutativity appears due to second class constraints via Dirac brackets), it has been demonstrated that non-commutativity actually follows from a careful consideration of the boundary conditions of the string model. Scientists of S. N. Bose National Centre for Basic Sciences, Kolkata have collaborated on these projects.

As a continuation of earlier work, a fully covariant quantization of the spinning particle model has been performed. This model is also of interest in the context of physics in NC space-time. Furthermore, some phenomenological consequences of NC chiral anomaly are being studied.

Quantum Mechanics and Quantum Optics

A number of results relating to exact solutions in the area of supersymmetric and PT symmetric quantum mechanics were obtained. Some results on periodic potentials with PT symmetry have also been obtained. Lie algebraic techniques are now being applied to Schrodinger equations with position dependent mass which have applications in semiconductors, quantum dots, liquid crystals, etc.

WKB and SWKB formulas have been derived for confined quantum systems in two and three dimensions. These formulas have been applied successfully for Harmonic Oscillator and Hydrogen atom in confined systems. An attempt is being made to apply these formulas for different radial systems and in two-dimensional problems.

Based on the nonlinear realization of the SU(1, 1) algebra, interpolating minimum uncertainty states which interpolate between the coherent states of the Heisenberg Weyl and SU(1, 1) algebras have been introduced and study of their quantum statistical properties is under way. Also, coherent states of the Morse potential have been obtained using the Gazean-Klauder formalism and some properties of this coherent state have been studied.

Another area of quantum physics which has been studied is total and fractional revival of quantum systems.

Theoretical Plasma Physics

Solitary waves and double layers in non-linear plasma dynamics are very important areas of research with application in astrophysical and laboratory plasma. Recently a new technique has been developed to derive Sagdeev's equations for a dusty plasma in electromagnetic field taking into account the dust charge fluctuation. This will be very useful to study double layers in dusty plasma.

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 hydrodynamical system was 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

The analyses of the oncoming spurt of the latest RHIC data on multiparticle production phenomena have been the prime focus of work in this area. Besides, the uptodate data on interesting physical observables available from other particle and cosmic accelerators have also come under the purview of recent theoretical studies undertaken in the Unit. The work paved the way to obtain some viable and tangible solutions to a few complex problems which are most topical in nature.

Study on a Deformed Hilbert Space

Homodyne statistics of a vector on a deformed Hilbert space has been investigated.

Interacting Fock Space

Coherent states and squeezed states have been formulated in interacting Fock space. Investigations are being made on Kerr states in this space.

Fluid Mechanics & Applied Mathematics

Basic Fluid Flows

Industrial fluid mechanical problems were modelled with a view to understand the physical processes involved in their applications. In spin coating process, if the initial distribution is non-uniform then surface tensions help in thinning the film while viscosity slows down the thinning process. Further, it was found that final film thickness is insensitive to the initial amount of liquid deposition. It was also found that the final film thickness is uniform and does not depend on whether the initial deposition is planar or non-planar.

Hydrodynamic Stability and Waves

In the context of designing heat exchangers and condensers, flow instability and formation of waves and their interactions on thin film of fluids flowing down a vertical / inclined plane are of current interest. In this

field, it is possible to identify different wave processes that form due to combined variation of Reynolds, Weber numbers and angle of inclination. It was found that, at small flow rate, kinematic waves dominate the flow field and energy is acquired from the mean flow, while, for high flow rate, inertial waves dominate and the energy comes from the kinematic waves.

Dynamical Systems & Chaos

Modelling various physical problems by dynamical systems helps capturing the underlying mechanism of the bifurcation involved. Chaotic competition between wavy-rolls and squares in zero-Prandtl-number connection has been studied. 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 pulsatile flow of blood in a constricted tube was studied in the first model. The effect of a magnetic field on the steady flow of blood in arteries was investigated in the second model.

Besides the above models, the computation on the flow of Bingham fluid through a circular tube of non-uniform cross-section and the investigation of convergent-divergent channel flow by decomposition method was carried out.

Laminar & Turbulent Flows

The boundary layer problems of laminar Newtonian and non-Newtonian fluid flows over stretching sheet are important both from theoretical and practical points of view. Assuming variable viscosity, the effects of a transverse magnetic field on the velocity distribution and associated temperature field for the viscous incompressible conducting fluid flow over a heated stretching sheet have been studied in detail. Also, the effects of a transverse magnetic field on the concentration distribution in the flow of a conducting viscoelastic fluid, undergoing first order chemical reaction and past a stretching surface have been determined with the help of a finite-difference computational scheme. The problem of turbulent bubble plume, was being pursued, using energy method.

Water Waves

Water wave scattering problems involving obstacles in the form of an inclined plate submerged in finite depth water and curved thin plate in the form of a circular arc elliptic plate submerged in deep water, have been investigated. Linearised theory of water waves has been assumed. The problems were formulated in terms of hypersingular integral equations on the discontinuity of the potential across the barrier. A finite series involving Chebyshev polynomials multiplied by appropriate weight functions was assumed for the discontinuity, which was then found numerically. Once this was found, physical quantities of interest such as the reflection and transmission coefficients were estimated numerically for various configurations of the barriers. This method is also being employed to investigate scattering by two symmetric plates or curved barriers.

Integral Equations

Singular integral equations and hyper-singular integral equations arising in water wave problems have been investigated.

Solute Transport

Numerical simulation on contaminant dispersion has been carried out in steady/unsteady laminar flows in annular geometry in the presence of chemical reaction or boundary absorption. The results of the study are likely to be of help in understanding the interaction between the flow and dispersion in a catheterized artery with conductive walls. The study of longitudinal dispersion of a tracer in annular geometry has a wide range of applications in the field of chemical and environmental engineering, biomedical engineering and physiological fluid dynamics.

Interdisciplinary Research

Category Theory & Brain Function

The different levels of activities of the brain have been studied using the sheaf cohomology. The possibility of assignment of geometric structure for different cortical areas of the brain is also under present investigation.

Hydraulic Flume

A mathematical model based on turbulent diffusion equation has been developed to compute velocity and sediment concentration profiles in open channel flow under the influence of bed roughness. The model has been verified with experimental data collected from ISI flume experiments conducted over five different sediment beds of heterogeneous grain sizes under controlled conditions.

System and Control Theory

The areas of interest are: developing numerical methods for analysis and designing and development of multivariable control systems. Work has been done on Descriptor variable systems and Matrix second order systems. Methodology has been developed to design controller for descriptor systems. Work to design observer for matrix second order system has been carried out. Studies have been made on digital and adaptive control systems.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes covering plant and animal kingdoms, including humans. It comprises the following units : Agricultural Science Unit, Anthropology and Human Genetics Unit, Biochemistry Unit, Biometry Unit, Chemistry Unit, Embryology Unit and Plant Chemistry Unit. Faculty members of all units participated in teaching various courses of the Institute and of other organizations. They were also actively engaged in guiding research of Ph. D. students. Research activities carried out in these units in the form of various projects are described below.

Agricultural Science Unit

Research Activities/Projects Undertaken

Studies On Sustainability Criteria In Rainfed Eastern Plateau Area

To achieve livelihood through subsistence farming in risk prone fragile ecosystem, low input technologies well suited to soil-weather-crop variables and having potential towards contributing to productivity, stability and equity were evaluated and transferred to the farmers. Field trails undertaken during this period established low input appropriate technologies in subsistence farming in relation to crop management and increasing soil health through integrated nutrient management practices. Use of genetic marker to locate potential germplasms has also been initiated.

Work on the Family Palmae

Next to Graminae, the family Palmae is composed of the most economically important groups of tropical plants, which are a major source of food, and raw material that remains under-explored. Three economically important semi-xerophytic palms, i.e. *Borassus flabellifer, Phoenix dactylifera* and *P. sylvestris* are being introduced in the ISI Giridih Farm, since they can grow in very dry semi-arid areas where the annual rainfall is less than 750 mm, to study their physiology, propagation and utilization aspects. The process of introduction is in progress.

Introduction of Oil Palm and High Yielding Coconut Cultivars in the Sundarbans Area of West Bengal

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The data collection in respect of number of leaves, height, girth at the base of stem, flowering time, photosynthesis performance, number of male and female bunches (for oil palm) and number of nuts produced per

coconut plant per year, etc. have been completed. Data analyses have also been completed. The final project report is under preparation.

Eco-floristic and Anatomical Investigations on Mangroves of Sundarbans

In ecophysiological work, osmotic potential of roots and leaves in mangroves of Sundarbans as well as from fresh water condition has been critically studied. This study has shown high negative osmotic potential both in leaves and roots, which enables them to cope up with high salinity stress of the substratum. Six types of free amino acids were estimated from the leaf samples of different mangroves. These amino acids, particularly proline, act as an osmoticum. Photosynthesis, transpiration, and stomatal conductance were studied in 16 mangroves in two different seasons. Protein profile has been studied from leaves of some mangroves grown in Sundarbans as well as in fresh water condition to find out the proteins responsible for salt tolerance of these halophytes.

Forest community structure and species distribution in seven new sites of Lothian Island was studied. Soil salinity decreased with increasing distance from the tidal coast. Soil salinity and pH affected species distribution of mangroves.

Work On Human and Insect Olfaction

Genetic basis of human and insect anosmia has been studied with the help of a variety of olfactory behavioral assays. A large-scale human survey on anosmia for five different dilutions of six pure and mixed olfactory ligands has been completed. A reliable estimate of anosmia in Indian population has been found, against the aforesaid olfactory ligands at different concentrations of the odorants, not reported earlier in the scientific literature. It has also been possible to show that the threshold concentration of different hydrocarbons used in the study follows a distinct pattern at least at the peripheral (olfactory epithelium) reception level.

Sense of smell is one of the primordial senses in insects. Store grain pests such as common rice weevil or *Sitophilus oryzae*, cause almost 25% of seed or food grain loss in the seed stores around the world. Except toxic fumigants like Aluminum phosphide, there are no effective control measures for these insects. This issue becomes more complicated as the stored seeds or food grains are used for human consumption too. Therefore an effective biological control measure is urgently needed. Olfactory neuro-behavioral assays have been used as tools to develop an effective biopesticide/biorepellent against these insects.

First, five different pure odors at different dilutions on a genetically heterogeneous population of common rice weevil, *Sitophilus oryzae* were used to standardize the assay system. Then different Indian herbs and plants were used for generating three novel biopesticide/ biorepellents in this paradigm. Currently, these novel formulations are being tested at the field level with the help of the West Bengal State Seed Corporation. This project is being carried out with the active support from the Department of Biochemistry and Guha Center for Biotechnology, Calcutta University, as well as the West Bengal State Seed Corporation.

Anthropology and Human Genetics Unit

Research Activities/Projects undertaken

Effects of Microenvironmental Factors on Health

An anthropological investigation conducted in the 24 Parganas (South) district of West Bengal reveals that the effect of mother's working status and education showed statistically significant differences in fertility among the working and non-working and literate and non-literate Pod (Poundra Kshatriya) mothers, while no statistically significant difference was observed among the Munda. Significant difference in infant and child mortality among the working and non-working Munda mothers were observed, but not among the Pod. Significant difference in child mortality was observed among the literate and non-literate Munda and Pod mothers. Infant and child mortality in both the ethnic groups were not significantly related to level of poverty. Literate and above poverty level mothers in both the ethnic groups revealed better health status than their non-

literate and below poverty level counterparts. The working Munda mothers and non-working Pod mothers have better health status in terms of greater percentage of normal BMI.

Factors like mother's working pattern, education, poverty level, child-care, immunization, time allocation, delivery practices and treatment showed differential effects on the health status of the mothers and their children below 5 years of age. The anemic status of the mothers of the "under-five" children showed greater percentage of anaemic Munda mothers, than Pod mothers. The degree and strength of relationship between the variables are being analyzed to examine the cause and effect relationship between the various micro-environmental factors on the health status of mothers and their children in both the ethnic groups.

Growth Studies

Collection of physical growth data among the children of Kolkata was completed on 22 measurements from 1129 male subjects aged 6-16 years. 349 families of the measured subjects have been visited to collect socioeconomic and demographic data. In addition, 256 subjects have been measured on two occasions with an interval of one year to estimate the single year velocity data. With respect to growth study of the adolescent girls, preliminary socio-economic and demographic questionnaires have been canvassed and the results have been tabulated. A female anthropometric measurer has been trained to conduct the measurement session shortly.

Epidemiology of Health of Tibetan Refugees in Exile

The Tibetan refugees in exile residing at Chandragiri, Gajapati district in Coastal Orissa have been selected. So far demographic and socio-economic data and information on disease pattern and prevalence among the entire Tibetan population of Chandragiri (Total 590 households comprising about 3000 individuals) were collected. The refugees are essentially high altitude natives and are at present exposed to a drastically different disease and nutritional ecology as well as cultural milieu. It will be worth investigating how they are coping with the new environment (low altitude, coastal hot and humid clime) and the strategies for survival in a changing situation.

Genetics of Dermal Ridges

Sex dimorphism was investigated in individuals drawn from five endogamous populations inhabiting West Bengal. All populations showed a homogeneous distribution pattern indicating common characteristics of dermatoglyphic traits within the same geographical area. But sex differences display different levels when compared with other racial groups which suggests that the sex differences are different in diverse populations. The interpretation may be the existence of possible role of environmental prenatal factors in the realisation of the level of dermatoglyphic sex differences.

Sex differences in asymmetry indices are less pronounced, which indicates that Indian populations are less asymmetric compared to other ethnic populations. Fluctuating asymmetry is greater in females compared to males, which supports the hypothesis of Livshits and Kobyliansky: increased heterozygosity is often associated with a decreased phenotypic variability including a diminished fluctuating asymmetry.

Relationship between Modernity of Lifestyles and Health Status in a Tribal Community in the Sikkim Himalaya

Under this theme a project titled "Modernization and Health in the Sikkim Himalaya" is being conducted. During the period between April 2001 and March 2002, data on dietary habits and practices, physical activity pattern, perceived stress, blood pressure, blood glucose, blood lipids, ECG and anthropometrics have been collected from about 85 selected Bhutia households located in Ralong Block, South Sikkim. Data analysis is in progress.

The interim analysis of the data reveals: (i) Prevalence of Essential hypertension among the urban adult Bhutias of both sexes is high (25 %) by WHO criteria, (ii) Blood pressure (both systolic and diastolic) of urban

Bhutias increases with increasing age, (iii) Prevalence of diabetes and that of hyperlipidemia among the urban Bhutias are high, (iv) Prevalence of severe obesity among the urban subjects is found to be around 10% , (v) Gastritis, Gastric/peptic ulcer, hypertension, pain in joints, visual disabilities are some of the notable diagnosed ailments of the urban Bhutias.

Women's Studies : Health and Well-being

The focus of the study is on the dynamics operating in the dual career families residing in Kolkata and ethnically/culturally different families in Gangtok. The objective is to examine the quality of life as experienced by couples in terms of the impact of work and non-work variables on career satisfaction, life satisfaction, physical and mental health. Data collection among 410 dual-earner couples residing in Kolkata has been completed. Analysis of the data is being done.

Genome Diversity Studies in Ethnic Populations of India

The evolutionary histories of ethnic populations of India have remained an enigma. Various anthropological theories have been proposed regarding the antiquities and origins of the different tribal and caste populations of India, who socio-culturally and linguistically belong to several broad classes. With a view to reconstructing the peopling of India and migrational trails, a project has been undertaken that seeks to evaluate the genomic diversities, compositions and affinities among ethnic populations of India. Blood samples were collected from about 50 ethnic populations, representing all geographical regions of India, as also socio-cultural and linguistic groups. During the year, a large amount of mitochondrial sequence data, Y-UEPs and Y-STRs have been generated. These data are currently being statistically analyzed. A project has also been initiated to discover and validate single nucleotide polymorphisms in genes related to various common diseases. Further, to test the hypothesis that there is no intrinsic resistance to HIV infection among various ethnic groups of India, the CCR5 gene has been screened. Further, the 32-base pair deletion in this gene, that is protective against HIV, has not been found in any significant frequency in any of the ~50 ethnic groups that have been tested.

Origin and Genetic Composition of the Lyngngam of Meghalaya

The project focusses on tracing the origin of the Lyngngam using genomic data. A large number of blood samples had already been collected and analyzed earlier. About 200 more blood samples have been collected during 2001-2002, supplementing the already collected 420 blood samples from Lyngngam and 7 other subtribes of Khasi and Garo. DNA extractions and typing of about 600 samples from a total of 9 tribes have been completed at CCMB, Hyderabad, for mtDNA HVR I&II regions and 9bp deletion, certain SNPs and biallelic markers (10), STRs on Y-chromosome (6) and for 9 autosomal STR loci. During the year, demographic data have been analyzed for admixture patterns and for clan and surname interactions. The statistical analyses are in progress.

DNA polymorphisms in the caste and tribal populations of Andhra Pradesh

About 1600 blood samples representing 35 castes and tribes of Andhra Pradesh have been collected. DNA extraction of all the 1600 blood samples has been completed in collaboration with CCMB. DNA sequencing of the above samples for Hypervariable Regions I & II of the mtDNA D-loop has been completed, besides typing of the samples for 9bp deletion in the intergenic COII/tRNA lysine. Analyses of the Y-based STRs, SNPs and bi-allelic markers have just been taken up, besides the 9 Amp FISTR autosomal loci for which data on 18 other populations is already available.

Health-Productivity Relationship

It is intuitively understandable that nutritional and health traits are important determinants of the human ability to perform hard and prolonged physical activity, in addition to some socioeconomic and cultural factors. However, such relationships have not been adequately tested and worked out with empirical data, particularly in respect of specific types of job and health measures in the Indian context. In view of these, the present project was undertaken to examine the health-productivity relationship, if any, among the brick field labourers of Jalpaiguri district of West Bengal. The labour group consists mainly of three ethnic groups, viz. Santal, Mech and Oraon.

After removing the effect of age from all the variables, no significant differences were found to exist between high and low productive groups in any of the traits under study. Step-wise regression analysis of the data shows that out of 45 variables, 5 variables significantly determine the productivity in males and in females only one variable significantly determines the productivity. In males, transverse chest diameter, skinfold thickness triceps and subscapular, back strength and age determine the productivity. In females, the more the haemoglobin level the more the productivity.

The Genetic Structure of Populations: The Effect of Mating Patterns on Genetic Structure of the Tribal Khampte of Arunachal Pradesh

Fieldwork was conducted during November and December 2001 in Arunachal Pradesh, especially among four villages of Adi-Pasi tribal population near Pasighat, East Siang District. The Adi-Pasi is a splinter migrant group, which settled at these four villages several generations ago from their original settlements in the upper hills of East Siang District.

Household demography and information about the marital patterns of the population were collected during the fieldwork. The four villages of Adi-Pasi have a population of 618 with 295 males and 323 female members. Apart from the four villages, several people live near Pasighat town. 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. The data collection is in progress.

Genetics of Oral Cancer

Collection and DNA analysis of patients with oral carcinoma and precancer lesions are in progress. In particular, examination of those genomic regions that are involved in metabolizing toxic substances is being done. The study is being conducted in Kolkata city.

Statistical Genomics

The primary focus is on evaluation and improvement of existing methodologies for evolutionary and demographic inferences based on DNA sequence data. A comparison was made between two popular methods for estimating TMRCA and it has been found that neither works well uniformly under all evolutionary scenarios. Currently, efforts are on to suggest an improved method.

Biochemistry Unit

Research Activities/Projects Undertaken

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

Many women are exposed to high-risk HPV (major etiologic factor of cervical cancer) during their lifetime. But only a fraction of infected individuals develop cervical cancer after a long latent period, indicating that the genetic background of the host influences the persistence of HPV infection with the onset of cervical cancer.

The objectives of the project are to study a few of the host factors, such as HLA types, p53 mutations, etc. in order to understand the specifics of HPV-infection, its integration and the disease expression. This will contribute towards the prevention of cervical cancer, which is the foremost cancer among Indian women. The work has been initiated in 2001 and some data on HLA & p53 polymorphism are in the process of being analysed.

High Risk HPV-Infection and the Natural History

Independently, 9-10% of the normal women having age $\leq$ 23 years were found to be infected with oncogenic HPV and 5% women in the age group $\geq$ 44 years displayed cytological abnormality. In women displaying cytological abnormality, increased number of childbirth at younger age increased the risk for

developing progressive pre-cancerous lesion. A data based cost-effective screening strategy for cervical cancer using HPV-testing and Pap smear has been proposed. The findings are useful in relating overall women's health issues in India.

HPV Infection and Cervical Cancer in the Northeastern States of Manipur and Sikkim

During November 2000 to March 2002, information and samples were collected and processed on 50 cervical cancer samples and 214 cervical scrapes from normal women (aged 25-75 years) in Manipur. Approximately 43% oncogenic HPV-infection was present in the cancer samples and 5% in the normal samples. Also, data and biological materials were collected from Sikkim on more than 100 subjects which are currently under experimental processes. Sikkim is a newly added State in this programme.

Human resource development has been an important part of the study. A student has been undergoing training on the program "Human Papillomavirus and Uterine Cervical Cancer Problem in Manipur". She is a recipient of Lady Tata Junior Research Fellowship.

Biometry Research Unit

Research Activities/Projects Undertaken

Fishery Science

Conventional but sophisticated statistical methodologies were applied to longitudinal growth data analysis of the Indian major carps. In addition to Time Series data analysis, Zerbe's nonparametric procedure has been applied to diagnose abnormal growth of carps. This has positive bearing on 'lag phase' of carp growth during the early developmental stage. Analysis of directional data generated from a longitudinal carp growth study rejects the predominance of dissolved O_2 content in the ambient water.

Biomedical Sciences

Juvenile MRDM with Dietary Errors

Work on the different aspects of Malnutrition Related Diabetes Mellitus (MRDM), specially on Fibro Calculus Pancreatic Diabetes (FCPD), is being conducted. This is a new type of diabetes prevalent in the developing countries lying within the tropical belt. It has been detected in the northern and southern parts of India.

In West Bengal, the detection of this disease, the aetiology of which is not clear, has been made possible for the first time, by the Institute in collaboration with the School of Tropical Medicine, Kolkata.

Studies of Gymnema Sylvestre as Controlling Diabetes

Taking reference from Charak Sanhita of the Upanishad, one of the most common and widely available medicinal plants, viz. as Gymnema sylvestre [local name: Gurmur (Hindi), Mesho sringee (Bengali)] has been selected for studying its antidiabetic activities. The active principle of this plant has been found out and the work is in progress.

Studies on Hepatoprotective Activity of Neem (Azadirachta Indica) Leaves

Water soluble portion of alcoholic extract of neem leaves was found to possess significant hepatoprotective activity against paracetamol induced hepatic damage in rats. Besides, neem leaf extract also possesses significant blood sugar lowering, hypotensive, antiinflammatory, antiserotonin and hypolipidemic activity.

Chemical analysis revealed that the extract contains a mixture of six flavonol-O-glycosides which are collectively known to be responsible for blood sugar lowering activity.

Besides hepatoprotective activity against paracetamol induced hepatic damage in rats, investigation on the effect of neem leaf extract on other models of hepatic damage, chemical constituents responsible for this activity and possible mechanism behind this action is under progress.

Physical Effects of PEMF Therapy in Bony and Rheumatological Diseases to Enhance Healing.

Pulsed Electromagnetic Field (PEMF) therapy is a late nineteenth century development and a new biophysical tool for healing of tissues or regeneration of body parts. In the pilot study, it was observed that PEMF therapy has a significant effect on Rheumatoid Arthritis patients. In order to find out the therapeutic effectiveness of PEMF therapy, further studies on RA as well as on Osteo Arthritis (OA) patients are in progress.

Chemistry Unit

Research Activities

Level and State of Existence of Heavy Metals Related Micronutrient Elements in Some Soils of West Bengal.

Surface soil samples from the coastal sites of West Bengal were studied for the total and available micronutrients status in relation to important soil characteristics. All the soils were found to have sufficient quantity of available Iron, Manganese and Copper but appeared to be deficient in available Zinc.

The status of Molybdenum was studied in broadly classified soils of four groups, namely Alluvial (e.g., Maldah), Lateritic (e.g. Nalhati), Foot Hill (e.g. Jalpaiguri) and Hill (e.g. Pedong) soils. Very low amount of molybdenum was present in these soils and they were highly acidic to moderately acidic. The assesment of trace elements in soil provided base line information of soil characteristics with respect to changes in soil composition produced by elution, plant uptake and agricultural manipulation. Plants require molybdenum in smaller amounts as compared to boron, manganese, zinc and copper.

Embryology Unit

Research Activities

Harmful algal blooms (HABs) have adverse effects on human health, commercial fisheries, recreational fisheries, tourism, coastal recreation, coastal economics and environment. Nations throughout the world are facing a diverse array of toxic or harmful species and in this regard India is poorly prepared. Researchers are trying to establish that viral infection on plankton plays an important role for the termination of blooms. Using field and laboratory based study as well as mathematical and stochastic modelling, an alternative approach has been established (the effect of toxic chemicals on zooplankton as against viral infection on phytoplankton) to explain the mechanism for the occurrence of planktonic blooms and its possible control.

A phytoplankton-zooplankton system was proposed taking into consideration that some of the phytoplankton cells are infected due to viral infections. Conditions for the coexistence of the populations were worked out. Some other models of phytoplankton-zooplankton systems with viral infection were also considered. It was concluded that role of viral infection in planktonic community is very much unpredictable and model dependent.

Plants liberate different metabolites via root exudates and as leaf leachate into the soil and such substances may significantly affect the growth of other neighbouring plants and thus allelopathy plays an important role in agriculture. Allelopathic activity has been studied mainly in weed-crop interaction. Caffeic acid and Sinapic acid have been identified from *Leonurus* and *Chrozophora* weeds. These allelochemicals show concentration dependent inhibitory-stimulatory activity. Allelochemicals can be used as growth promoters based on beneficial effects and as biopesticides based on inhibitory effects.

Plant Chemistry unit

Research Activities

Screening and Agronomic Studies of Various Plant Species

A short term in vitro study, as well as a long term study in terms of biodegradation and mineralization process using forest leaf litter in different zones of soil forestry circle has been undertaken. In short term study litter was mixed with inoculum and in long term study, litter bag with leaf litter has been kept in the soil environment and colonization pattern was observed on monthly basis. Microflora was screened, characterized and ability to form cellulolytic, proteolytic enzymes was carefully investigated. *Trichoderma, Neurospora, Alternania* were efficient producers of cellulolytic enzymes. Relative prominence of the microbes was worked out in terms of the frequency (%) and relative abundance. Two actinomycetes taxonomically designated as streptomyces sp S_3 and S_4 were isolated from leaf litter compost. Their morphological, biochemical characterization and electron microscopical studies have been done.

Microbial Studies of Leaf Protein by Product and Soil Microbes

Prior to microbial enzymatic conversion of lignocellulosic wastes to fermentable sugars, an investigation on chemical profile studies was undertaken to assess the actual makeup of wastes. The agricultural wastes were collected after crop harvest. Dried stack from Mustard, Kulthi, Soyabean and Blackgram were analyzed critically for individual component ash (1.27-7.24), lipid (5-8.5), nitrogen (0.53-1.51), holo cellulose (66-76), lignin (15.15-26.35) and α-cellulose (35.6-42.9). Data are represented as % of dry weight. Population dynamics of proteolytic bacteria in jute field and paddy field were studied along the alluvial soil of West Bengal in detail. A detailed investigation on a protease production by *Bacillus lichemformis* S-ch-5 was done. Important cellulose degrading strains were identified as *Trichoderma, Neurospora, Aspergillus, Penicillium, Fusarium* and *Humicola, Bacillus, Pseudomonas, Cellulomonas, Steptomyces* and *Thermoactinomyces*. Most of the microbial strains screened were proved to be efficient cellulase producers as indicated by their enzyme assays - CMCase activity (0.31-4.6 IU) F Pase activity (0.2-3.5 IU) and β glucosidase activity (0.29-4.5 IU).

Aquatic Weed and Water Relationship

Collection of baseline data for three years on aquatic plant growth and water quality in two ponds has been completed in June 2001. Some interesting relationships, as given below, were found after preliminary analysis of two years' data – (i) Improvement in clarity of pond water with the presence of submerged weed, (ii) Inverse relationship between coverage of duckweeds and dissolved oxygen content and (iii) Ability of submerged plants to maintain water clarity even at high nutrient concentrations.

Yield Performance of Sugar Beet

In comparison to variety Ramanskaya 06 the other sugar beet (*Beta vulgaris* L.) varieties, namely Raspoly, Solid and Maribomonova showed better performance in last year's experiment. Particularly for root and sugar yield, variety Raspoly showed better performance than Ramanskaya 06. For Leaf Protein production from sugar beet, the variety Maribomonova produced good quantities of protein. In the year under review, three varieties, namely FD CR 0018 (resistant to *cercaspora*) FD RH 0111 (moderately resistant to rhizomania) and FD 0133 (no particular resistance) were supplied by Florimond Desprez, France. The sowing has been done in early November 2001. Five nitrogen doses (0, 40, 80, 120 and 160 kg/ha) with three potassium doses (50, 100 and 150 kg/ha) with fixed phosphorus dose of 60 kg/ha were used. These fifteen treatment combinations with three replications will be studied under FRBD (Factorial Randomised Block Design) experiment. Data will be collected for various yields (root, shoot, sugar concentration, total sugar, dry matter, fibre, and leaf protein) in each 20 day interval starting from 75 days after sowing and up to 165 days of the crop.

Social Sciences Division

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Linguistic Research Unit, Planning Unit, Population Studies Unit, Psychology Research Unit and

Sociological Research Unit. Economic Analysis Unit is located at Bangalore and Planning Unit is located at Delhi, while the remaining five units are located at Kolkata with Sociological Research Unit having a branch at Giridih, Jharkhand. Faculty members of this Division participate in teaching and training activities at various levels, including Ph. D. supervision. Research work done in these units during the year under review is described below.

Economic Research Unit

Research Activities

The main areas of research undertaken during the 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. Examples of some of the particular problems that have been focussed on are: efficiency pricing for infrastructure in a growing economy, generalisation and policy application of Human Development Index, the econometrics of yield spread in money market, econometric analysis of causality between income and emission, identification of restrictions on utility function which guarantee that a more progressive system of taxes results in less social deprivation, characterization of the variance as an absolute index of inequality, analysis of individual voting power and power of collectivity to act.

These researches have been published/accepted for publication in international journals like Review of Development Economics, Economic Theory, Mathematical Social Sciences, Journal of Income Distribution, Keio Economic Studies, Hitotsubashi Journal of Economics, Ecological Economics and Journal of Public Economic Theory.

The ERU faculty has been teaching various courses in economics and econometrics for the B.Stat.(Hons.), M.Stat., M.Tech.(QROR), ISEC(regular and specialization) and MS(QE) programmes. Five research fellows are working for their Ph.D. under the supervision of members of the faculty of ERU. One faculty member has been working as an external evaluator for World Bank Projects.

Projects Undertaken

Price Seasonality, Storage and Speculation

The project has been completed and the report titled "Information, Prices and Profitability - Evidence from Selected Potato Markets in West Bengal" has been submitted. In this study the cost, revenue and profit related to potato production across various classes of producers have been estimated. It has been shown that traders earn higher profit per unit of output. Large sellers too earn higher profit compared to small sellers because they possess better information about demand and supply conditions of the market. An estimate of profit earned from pure speculation is also provided in this study. The study is based on a survey (of two years duration) and a theoretical model has been developed based on the empirical findings.

Environmental Management Capacity Building Technical Assistance Project - Environmental Economics Component.

This is a World Bank aided project assisted by IDA and funded by World Bank which is being implemented through the Ministry of Environment and Forests, Govt. of India. The duration of the project is five years beginning 1997-98. The Economic Research Unit got involved in the project in 1998. The broad objective of the project is to strengthen the environmental management capability of the country. The environmental economics component mainly aims at enhancing the capability for the application of economic principles and tools to environmental management problems across the full range of issues such as cost-benefit analysis of alternative policies for pollution control, resource management and biodiversity conservation. A faculty upgradation programme on environmental economy of one month's duration for the Post-graduate level teachers has been conducted under this project. Also study on "Rural electrification with solar energy" in the Sagar Island has been conducted under this project. The report of the study is under preparation.

Economic Problems of Illiteracy

This is an ongoing project based on selected villages in Assam. The purpose of this project is to test 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 has been completed.

Externally Funded Projects

Efficiency of Air Pollution Control Technology in the Iron Foundry Industry, Howrah

Being declared as 'red category' industry for discharging hazardous substances in the environment, regulatory measures were implemented for compulsory use of controlling device for control of air pollution in the iron foundry industry all over India. But the choice and adoption of controlling device involve cost, which affects the production decision of the owners. Therefore, a comparative analysis of costs and benefits arising out of such additional investment has to be made. The present study was undertaken (i) to evaluate the efficiency of the pollution controlling technologies used in the foundry units located in Howrah district of West Bengal in terms of their technical efficiency to clean the air according to the regulatory authority's prescribed norms and (ii) to estimate the economic feasibility and social significance in terms of actual benefit that accrued from such additional cost.

The results show that the efficiency of the controlling device not only depends on the technology but also on the rate of generation of pollution, which is dependant on input-quality as well as production technology. The choice of controlling technology is also affected by the cost of device as well as capacity utilisation of the production system.

Economic Analysis unit

Research Activities

The Unit is actively engaged in research in frontiers of quantitative methods in Economics and Social Sciences. Application of Bayesian methods to different problems in Agriculture, Industry and National Income accounts is being actively pursued. Topics in Agricultural economics, Applied Computable General Equilibrium Models and quantitative methods in Informatics are of current interest.

The Unit has also doing some research in topics that would be described as foundations of econometrics. Transfer Pricing, an emerging area of work in Finance is being pursued by the research scholars of the Unit.

The Unit has been working on developing a software for use of Bayesian econometrics.

Linguistic Research Unit

Research Activities

There are seven main topics under which the Unit's research projects may be grouped, which are listed below.

Computational Linguistics

Valency-based Natural Language Processing, Fuzzy Logical Expressions in Bangla, Problem of Conceptual Tense and Aspect vis-à-vis Grammatical tense in Bangla Discourse.

Methods in Quantitative Linguistics

Quantitative Constraints on case assignments in Bilingual discourse, Models of rank frequency distribution, Research design in applied linguistics, Text as a linguistic paradigm.

Sociolinguistics

Study of Language attitudes, Language maintenance and shift, measurement of bilingualism, Linguistic sub-alternity and decentralized Language planning in a plural society. Analysis of Folklore and Folklanguage. Cultivation of Mother-tongue and interference, Language Standardisation.

Clinical Linguistics

Aetological and Diagnostic approaches to Speech Pathological Problems, Habilitation of hearing impaired children.

Psycholinguistics

The relationship between "empty linguistic organism" and "social malleability": Psi-Properties, Second Language Acquisition.

Post-Structuralism

Post-formal Approach to Linguistics, Archaeology of Bangla Grammer.

Linguistics and Genetics: Linguistic Structure of DNA

This is an ongoing project in collaboration with Department of Theoretical Physics, Indian Institute for Cultivation of Science, Kolkata. The project tries to find out the selectional restrictions of different triplets by deploying Linguistic methods.

Projects Undertaken

Cognito-Quantitative Linguistics

By looking at existing corporus on Indian languages, efforts are being made to describe the surface structure of the narratives following the definition of Labov (1972) and Labov and Waletsky (1967) and the revised definition offered by Moller (1991).

Field work in different schools of West Bengal regarding Bangla-English interference is being carried out.

Subaltern Linguistics

Work has been carried out on various language movements – Boro, Bundelkhandi, Chattisgarhi, Gorkhali, Kamtapuri, Pahari, Asamiya and Santali.

Linguistic Ecology

Information is being gathered from electronic media and linguistic landscaping work is being carried out in Baroda, Hyderabad, Kanpur and Kolkata.

Integrated Programme for Hearing Impaired

Discourse oriented teaching aids are being prepared by organizing subject wise (literature) information in video.

Planning Unit

Research Activities

Members of the Planning Unit 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 Tesing 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.

Population Studies Unit

Research Activities

Breast Feeding Practices Among Weaker Sections in Kolkata Metropolitan Area and its Impact on Postpartum Infecundable Period

This study focussed on the breast feeding practices and its influence on post partum amenorhoea among residents in slum areas of Kolkata. Three out of four women initiate breast feeding after one hour of birth and three out of five women squeeze the first milk from the breast before breast feeding. Though the median duration of breast feeding is long, the duration of exclusive breast feeding or breast feeding with water only are much shorter. Breast feeding during the first six months has negative influence on the rate of return to menses .

Determinants of Child Immunisation in Four Less Developed States of North India

Utilising the data of National Family Health Survey India 1992-93, an attempt was made to study the extent of utilisation of child immunisation services in Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh. Findings from this study suggest that children of (i) couples where the husband is literate and the wife has at least middle school education, and (i) women who either receive antenatal care or delivered in the institutional environment, are more likely to receive immunisation.

Socio-Economic, Cultural, Demographic and Health Issues in the Stabilisation of Population in the North-East

Based on empirical analysis of socio-economic, cultural, demographic and health aspects of the seven north-east states in India, this study identifies the states which need immediate attention and intervention on selected developmental issues so as to avoid further deterioration of the population and the social scenario.

Demographic Profile of Meghalaya in the Perspective of its Socio-Economic, Cultural and Health Development

The study examines the demographic features of the state of Meghalaya and its temporal change in relation to socio-economic, cultural and health characteristics of the state. It shows that in spite of the state's positive socio-cultural features, its poor performance in the secondary and tertiary economic sectors as well as its poor performance in the public health and family welfare programme have been deterring NPP – 2000 goals.

Nepali Migration to India

In the absence of employment opportunity outside agriculture, Nepali hill people migrated to India and India became the safety valve for the Nepali's growing population. Increasing volume of Nepali migrants was noted in the periods 1901 – 11, 1921 – 31 and 1951 – 61 whereas decreasing trend was observed during the periods 1911 – 21, 1931 – 51 and 1961 – 91. Return migration of Nepalese was also estimated indirectly.

Digit Preference in Age Data : A Fresh Look

The method (Turner, S.H., 1958) comparing observed with proposed hypothetical ranking of ten digits of ages is critically reviewed in the present research. A more realistic approach is made taking into account ranking from the population being depleted by mortality in a closed population.

Estimate of 0 – 4 Population : An Application of Stable Population Model

Because of under-enumeration error, adjustment of 0 – 4 population is difficult. The present research tries to build up a model from stable population age distributions.

Projects Undertaken

Household Financing of the Reproductive and Child Health Care in Kolkata Slums

This study focuses on the morbidity and mortality patterns among slum dwellers in Kolkata by their socio-economic, cultural and demographic characteristics, finds out the health seeking behavior and the sources of care, investigates the means of meeting health care expenses and finally suggests alternative strategies for meeting the health care expenses incurred by poor slum dwellers. A preliminary report of the project is being prepared.

Determination of Risk Factors Associated with Maternal Mortality : An in-Depth Study in Kolkata Metropolitan Area

In-order to develop, implement and evaluate policy and understand causes of dying from pregnancy and child bearing, this study investigates elaborately 185 cases of maternal deaths which have occurred during last two years in Kolkata Metropolitan area through structural questionnaires for identifying risk factors.

It has been observed from the preliminary findings that the main causes of maternal death are anemia, tetanus, toxemia, unsafe abortion, obstructive labour, complications due to malposition of the child, haemorrhage and infection. Other risk factors responsible for the death are lack of access to health care services and trained birth attendants, low educational level of the household members, travel time, cost, physical torture of pregnant woman, malnutrition, pregnancies at younger and older ages, high parity birth, etc.

Undocumented Migration from Bangladesh to West Bengal

This study develops various techniques to estimate illegal migrants to West Bengal from Bangladesh. Data on documented migration, population, births and deaths have been collected from secondary sources to estimate undocumented migration after adjusting errors in the secondary data during 1951 – 91. Census survival ratio and other techniques are being employed for estimating undocumented migration. The project is continuing

Setting Directions for Future Research and Policy on Population Stabilisation in North-East India

Population stabilisation efforts in three north-eastern states of India, namely : Assam, Tripura and Meghalaya, are being critically reviewed in the study against the backdrop of their socio-economic status, ethnic and cultural characteristics, demographic and health features and environmental changes.

Data collection is complete in the above three states. The draft report of the project is being prepared for presentation in a workshop for key policy makers, planners, and implementors in the areas of population, health, economic and social development. This is an ongoing project.

Estimation of Volume and Socio-Demographic Transition due to Undocumented Migration from Bangladesh in North-Eastern India

Census information on population by language, religion, etc. since 1951 census by districts / blocks were employed to estimate volume of migration. Several methodologies have been explored to estimate the volume of undocumented migration. The search for developing suitable and appropriate technique to estimate undocumented migration is still on.

A two day workshop on "Economic and Socio-cultural transitions in North Eastern States of India" was organised at Guwahati. About twenty invited papers were presented and discussed in the workshop. This

workshop ended with the following concluding remarks : unemployment, economic deprivation, dissimilation of migrants with local people, political aspiration may be responsible for socio-economic tension due to undocumented migrants in the north eastern states.

Psychology Research Unit

Research activities

Digit Replacement Errors in Short-Term Memory

Data were collected from 75 individuals with computer-aided short-term memory tests. It was found that those digits which resembled each other physically and those digits the perception of which required similarity in eye movements tended to replace each other more than the other digits. Besides, some new digit recall errors were found. The findings are relevant for education through visual media.

Organizational Health and Job Satisfaction

Data were collected from 219 employees of regional rural bank, cooperative and commercial banks through organizational health and job satisfaction questionnaires. Results revealed significant differences in perceiving organizational health of employees of rural banks between employees with more job satisfaction and those with less. The findings are important for need based organizational design.

Clustering Months Using State Anxiety Data in the Antarctic Expedition

Data were collected from 18 members of the expedition on a specific day in each month of one year through Spielberger's State anxiety inventory. Dendogram prepared by hierarchical cluster analysis using single linkage procedure identified two clusters of months. Significant difference in state anxiety scores between the two clusters was noted. The findings are relevant for stress management in the Antarctica expedition.

Job Satisfaction of Computer Programmers

Data were collected from 201 programmers working with six different occupations through adjective checklist. Results showed that programmers preferred achievement, intellectual stimulation, creativity, skill utilization and effort than others. The findings are important for job design of computer programmers.

Projects Undertaken

Development of Computer Algorithm for Construction of Aptitude Test Battery for Computer Programmers

The project revealed (a) relative importance of computer programming tasks (b) relative importance of specific aptitudes (c) correlation between programming tasks and the aptitudes across six different occupations and provided a computer aided aptitude test battery. The findings are important for vocational selection and guidance for aspirants in computer programming.

Study of Invariance of Item Parameters Across Social Groups of Likert Type Scale : An IRT Approach

This project explored the estimation of item parameters following Item Response Theory (IRT) of graded responses (Likert type scale). This method provides relatively generalized measures of certain social-psychological attributes.

Development of questionnaire for assessment of reading and writing motivation of boys and girls of grades III and IV .

Two questionnaires were developed with 42 items (21 for reading motivation and 21 for writing motivation) and were administered to 538 students of classes III and IV of private and Government schools of

Kolkata and Howrah. Each questionnaire was measuring seven dimensions of reading and writing motivation. These dimensions were derived from content analysis of interview responses of students in an earlier study. Currently item analysis is going on.

Analysis of the results of Madhyamik Examination in West Bengal

Outcome of the project is expected to be very useful for policy decision with respect to pedagogy and evaluation of 'Madhyamik' curriculum and examination.

In the case of analysis, content of evaluation, multilevel determinants of students performance and cognitive mapping by applying IRT (continuously scored response model) appeared to be methodological development in the area of educational research.

Entrepreneurial behaviour and Individualism-Collectivism

Entrepreneurial behaviour and its relationship with different personality characteristics and Sindividualism-collectivist orientation has been studied in entrepreneurs of West Bengal and some North-Eastern States of India. The data so far analyzed reveal that entrepreneur's task motivation, locus of control and individualistic orientation are significantly related with the success of the enterprise.

A Study on the Socio-Psychological Aspects of 'Mental Retardation'

This was a socio-psychological study of moderately and mildly retarded children (I.Q. between 70-89 and age group 6-12 years), who are the largest group among the mentally retarded, in order to find out the underlying factors for their retardation and also to suggest their rehabilitation. Data have been collected from three South Bengal and three North Bengal districts. Scoring and evaluation of data are on progress and the report will be published soon.

Sociological Research Unit

Research Activities

Agrarian Change in Southern Tamil Nadu, 1977-2000

At the core of this project was quantitative and qualitative material gathered over 9 years (1977 to 1986) in the Cumbum Valley, an area of appreciable agricultural modernisation in the Theni District of Tamil Nadu, and in Gokilapuram, a village in the valley. This was followed up by a resurvey conducted in 1999 to track the dynamics of rural change in respect of the following socio-economic indicators: agricultural production, agricultural and non-agricultural employment, income and wage, distribution of land and assets, class and caste status and occupational mobility, indebtedness, literacy and education, and nutritional levels among children. Analysis of data from the resurvey and the survey of 1977 continued along with new case studies on agricultural workers as well as on new forms of rural employment. The features of both the economic histories of the region and its contemporary agrarian economy, were dealt with.

Agrarian Relations Seminar Series

Socio-economic changes in India require basic land and agrarian reforms and an end to caste oppression and gender discrimination in the countryside. While the development of capitalist relations in agriculture is clearly the major all-India trend, agrarian relations in India are marked by considerable regional and sub-regional diversity and by extreme unevenness in the development of capitalist relations of production and exchange. There is a long tradition of research on agrarian relations at the Indian Statistical Institute, beginning with the pioneering survey conducted in 1944 by Professor P.C. Mahalanobis on the impact of the Bengal Famine of 1943. The purpose of the seminar series is to provide a forum for debate and discussion on new theoretical and empirical research in the field of agrarian relations. The series will be multidisciplinary and concerned particularly with the dynamics of agrarian change. The invited papers were circulated and a selection from the

series is being processed for publication through a book. The first phase of the project was completed by March 2002.

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. A report is being prepared.

Gender and Labour: a Study of Mica Industries of Giridih

The purpose of the study 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 done.

Study of Rabindranath Tagore

This is a volume on Rabindranath Tagore in the series called *Modern Indian Greats* launched by Oxford University Press. The focus of the study is the explication of the two themes: (i) Tagore's free thinking and reasoning about nationalism and his indifference to political "solidarity", and (ii) his twin faiths in God and humanity. The proposing scientist has approached her study through her on-going research on (a) history of Tagore's educational institution at Santiniketan and Sriniketan (1901-1041) and (b) exploring encounters between Tagore and other important personalities in India and abroad, such as P.C.Mahalanobis and Edward Thompson. The study also includes a visit to Tagore's old haunts in East Bengal where he spent much of his life during 1890 and 1900 very close to rural life of Bengal which, the poet himself reflected, had made a lasting impact on his thinking about his country and its future.

Compiling an Annotated Bibliography of Rammohan Roy

This is a project to compile an annotated bibliography of the life and work of Raja Rammohan Roy (1772-1833) situating his pioneering contribution to religious, social and educational reforms in the context of the making of modern India. The project report has been completed.

Service and Supply to the Ceiling-Surplus Allottees in West Bengal

After the introduction of the elected Panchayat system in West Bengal, the drive for land reforms was strengthened. Along with 'Operation Barga', the thrust was given for distribution of ceiling-surplus vested land to the land-poor peasants and the landless labourers. It was hoped that these 'new owners' with the means of production under their control would not only improve their standard of living but also add to the production. Data indicate that production increased over time. The project seeks to ascertain what contribution to production was made in the vested land distributed among the new allottess. It would also probe whether the supply system to the owners of vested land was adequate for enabling the new owners to exercise the optimum control over the means of production. Report writing is in progress.

Empirical Study on the Labor-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 June 2002.

Study on Status of Women in West Bengal (funded by State Women Commission, Govt. of 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 and 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 June 2002.

North-East projects:

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 findings 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 proposed sample survey will be spread over the entire West Tripura District, encompassing both the urban rural areas. Data collection is over and data processing is in progress.

Participation of Women Members in Gram Panchayat - a Study of their Achievements in Tripura

The focus of the project is to study the role of women members of Gram Panchayats in Tripura since 1993, when their representation in Gram Panchayats increased due to reservation of seats as a result of 73rd Amendment to the Constitution. For case studies, six Gram Panchayats have been selected, taking three from each district of West and South Tripura. Questionnaire schedules have been used to assess women's awareness and participation in different activities and their ability to take decisions in public affairs.

The project would also ascertain whether increased role of women in the Gram Panchayat could significantly change the status of majority of women in the villages and enable them to obtain their legitimate rights from the society. One of the major areas of the inquiry will be to find out whether the women members in Gram Panchayats are now able to take decisions independently. The data collection is over and data processing is in progress.

Statistical Quality Control and Operations Research Division

The Division comprises 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. One of the primary responsibilities of the Division is to organise 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 the academic programmes of B.Stat.(Hons.), B.Math.(Hons.), M.Stat., M.Tech.(QROR) and research course for JRFs in addition to their research and project work.

The Division conducted a four-week training programme on "Recent Developments in OR" for 24 Officers of Batch XXIV of Indian Statistical Service probationers during 24 September-19 October 2001 at T & P Unit. Faculty assistance was also provided to the 55th term ISEC Regular Course on Statistical Quality Control (SQC) and Operations Research (OR). The T&P Unit also conducted the Specialisation courses on SQC & OR for the same batch during January – March 2002.

The scientific staff of the Division was engaged in research in the fields of Operations Research, Statistics, SQC and Reliability. The specific areas of research are Linear Complementarity Problem (which unifies Linear Programming problem, Convex Quadratic Programming, Linear Fractional Programming, Bimatrix games, etc.), Game Theory (in particular non-cooperative games and stochastic games, Integer Programming Problem, Combinatorial Optimization, generalised Convexity, Consecutive K-out-of-n: F System, Linear Models, Regression Analysis, Process Capability and Warranty Cost Analysis.

The faculty members are also engaged in imparting on-the-job training for fellows under Specialist Development Program (SDP) and a large number of personnel at all levels from industries and service organisations, in the application of Statistics and other Quantitative Methods for improving quality, reliability and productivity in particular and operational efficiency in general.

Bangalore Centre

Research activities

Semi-definite complementarity problem

Research in the area of semi-definite complementarity problem has continued. By introducing ultra P-properties of linear transformations, some interesting operator-theoretic and complementarity properties of some of the transformations like Lyapunov ($L_A(X) := AX + XA^t$), Stein ($S_A(X) = X - AXA^t$), etc., were deduced in terms of the matrix theoretic properties of A.

Global Univalence and Jacobian conjecture

Global Univalence results are being investigated in the case of non-smooth functions and the relationships between global univalence results and polynomial mappings and the Jacobian conjecture are being studied.

Projects Undertaken

A. Externally Funded Projects

ISO 9001 certification at Die Casting Division, HMT

The assignment was to implement ISO 9001-2000 quality management system. The organisation has been recommended for certification to the new system in April 2002.

Six-sigma at Reliance Industries Limited, Patalganga

The unit is engaged in implementing Six Sigma at Reliance Industries Limited in collaboration with SQC Unit, Mumbai. In the year 2000-2001, 16 projects were completed yielding a saving of Rs. 6.4 crores. 22 projects have been taken up in 2001-2002 with a projected saving of Rs. 5.2 crores.

QS -9000 certification at AT & S, Nanjangud

Here, the unit is engaged in implementing QS 9000 system as well as Six Sigma. The Organisation has been certified for QS 9000 in September 2001. Currently, Six Sigma implement projects are the main focus and 28 projects have been identified and black belt training is being provided.

Training Projects

Title	Dates	Venue
1. 1-day program on Six Sigma (10 batches)	04, 26 April, 2001 03, 10 May, 2001 07, 21 June, 2001 02, 11, 19 July, 2001 02 August, 2001	Ottobilz Ltd, Doddaballapur
2. 2-day program on Internal Quality Audit	27-28, April, 2001	Grasim Industries Ltd, Harihar

3. 2-day program on Six Sigma Implementation	04-05 May, 2001	Grindwell Norton Ltd, Bangalore
4. 1-day program for vendors on Quality and 7 QC tools	08 May, 2001	Lincoln Helios (India) Ltd, Bangalore
5. 5-day program on Design of Experiments	16-18 July, 2001 13-14 August, 2001	MICO, Bangalore
6. 2-day program on Taguchi Robust Design	06-07 July, 2001	TVSE Ltd, Bangalore
7. ½-day awareness program on ISO 9001: 2000 (2 batches)	03, 10 August, 2001	DCB-HMT Ltd, Bangalore
8. 1-day program on Six Sigma	08 August, 2001	Satyam Computers Ltd, Bangalore
9. 4-day program on Six Sigma	16-17 August, 2001 23-24 August, 2001	Satyam Computers Ltd, Bangalore
10. 1-day program on problem Solving techniques (2 batches)	01 August, 2001 07 September, 2001	IFB Industries Ltd, Bangalore
11. 1-day program on Process FMEA (2 batches)	08 August, 2001 06 September, 2001	IFB Industries Ltd, Bangalore
12. 1-day QS-9000 awareness program	16 August, 2001	IFB Industries Ltd, Bangalore
13. 1-day awareness program on ISO-9001: 2000 for top management	-	KAP India Ltd, Bangalore
14. 3-day Internal Quality Auditors program	-	KAP India Ltd, Bangalore
15. 1-day program on Six Sigma	07 September, 2001	MSIL, Bangalore
16. 1-day program on Six Sigma	08 September, 2001	Praxair Ltd, Bangalore
17. 11 half days program on Statistical techniques	11 half days	Ottobilz Ltd, Doddaballapur
18. 2 half days program on Simple QC tools	2 half days	Tata Tea Ltd, Bangalore
19. Summer School on Operations Research and its applications	18 June, 2001 - 7 July, 2001	ISI, Bangalore

Baroda Unit

Research Activities

Maintained systems and shock models with concave and log-concave life distributions

Of late reliability theorists have been showing considerable interest in non-parametric classes of life distributions that are not based on aging. Two such classes are log-concave and concave classes. Several inequalities involving the number of replacements in a maintained system where the inter-replacement times are i.i.d. with concave or log-concave distribution, have been derived. Life distributions arising from shock models have been studied and conditions leading to their concavity and log-concavity under generalized set-ups have been explored.

Six-sigma quality and its applicability in supply-chain management

The need for a comprehensive, flexible and adaptable framework for evaluating the performance of a supply chain has long been felt. A structured methodology with which performance of a supply chain and its entities can be effectively measured, monitored and improved with the help of six-sigma metrics has been developed. The model is being validated with real life applications.

Economic models for control of defectives in a manufacturing process

Under the assumption that the pattern of appearance of defects indicates a geometric process failure mechanism, an economic model for control of defectives has been developed in line with the method suggested by Taguchi and critically examined by Nayebpour and Woodall.

Projects Undertaken

Implementation of ISO 9000 Quality systems in ONGC

This is an ongoing project in which ONGC is being assisted to achieve the ISO 9000 certification.

Upgradation of ISO 9000 to the 2000 version at ORG-MARG Research Ltd

ORG-MARG Research Ltd., the largest market research organization in South-East Asia, could upgrade their existing ISO 9002:1994 certification to ISO 9001:1994 with the help of specialists from SQC & OR Unit, Baroda.

Implementation of SPC and MSA at Vijayjyot Seats Ltd

As a partial requirement of QS 9000 standards, SPC and MSA systems were implemented at Vijayjyot Seats Ltd. This helped the company achieve the QS-9000 certification as well as complete a number of quality improving and cost-saving projects.

Quality Improvement Projects at Apollo Tyres

At the instance of the top management, a number of quality improvement projects were taken up by teams of engineers and the teams were guided by ISI specialists to successful completion of projects.

Implementation of SPC systems at Philips Glass, Jammusar

This is an ongoing project, involving training of all engineers and implementation of SPC to measure and improve performances of all manufacturing processes.

Chennai Unit

Research Activities

Game Theory and Semidefinite Linear Complementarity Problem

Conditions were developed for coincidence of two different solution concepts in cooperative games, namely, the core and the stable set, both in TU and NTU games. Relationship was studied among various properties (like GUS, P_2, monotonocity) of different linear transformations like Lyapunov, Stein, Product, P.

Process Capability Indices

Relevance and appropriateness of existing indices were analyzed to assess their suitability in real-life situation; various evaluation methods for non-normal process were compared.

Warranty Cost Analysis

Reliability estimation from censored data under various warranty policies and Statistical modeling of two-dimensional policies were studied.

Coimbatore Unit

Projects Undertaken

Waste Minimisation Programme for Garment Industries, Tirupur

Studies have been undertaken to improve quality, simultaneously reducing cost and implementing system to the requirement of International Standards.

Implementation of ISO 9000 certification

The Unit worked and contributed towards implementation of ISO 9000 certification in six organisations.

SPC implementation

The project was carried out in eight organisations.

Training programmes on ISO 9000:2000 and SPC were conducted in five organisations for 50 executives and 300 workers.

Delhi Centre

Research Activities

Linear Complementarity problem and its generalizations

The matrix classes: fully semimonotone, fully copositive matrices and Q_0 matrices have been studied. Some special cases of Stones conjecture: $(E^0_r \cap Q_0) \subseteq P_0$ have been proved. Matrix classes like the positive subdefinite and pseudomonotone matrices are being studied. The question of processability of positive subdefinite matrices by Lemke's algorithm is being investigated.

Semidefinite Linear Complementarity Problem (SDLCP)

A generalization of linear complementarity problem SDLCP(L,Q) is being studied, where is a given linear transformation (S^n denotes the linear space of $n \times n$ symmetric matrices) and Q. The relationship between strictly copositive and strictly semimonotone transformations L is being studied. A characterization of self-adjoint semimonotone transformations L for which $L(X)$ is diagonal type was obtained. Linear transformations (for which every principal subtransformation is a diagonal type principal subtransformation) have been investigated.

Consecutive K-out-of-n: F System

Different formulae were obtained for the number of minimal path sets of a linear consecutive-2-out-of-$n:F$ system. The first formula is in terms of the binomial coefficients and the second formula is in terms of the number of minimal path sets with known size of a linear consecutive-2-out-of- system. The expression for the number of minimal path sets of a circular consecutive-2-out-of-$n:F$ system was also obtained.

Stochastic Games

Finite step pivoting algorithms have been obtained for computing the value vector and the associated optimal strategies of the players for some more special cases of zero-sum stochastic games. Similar algorithms have also been obtained to compute a Nash equilibrium point and the corresponding stationary strategies of special cases of non-zero sum stochastic games.

Projects Undertaken

Physical verifications of food grain in FCI godowns

SQC & OR Unit, Indian Statistical Institute, Delhi was entrusted by Food Corporation of India (FCI) to develop a cost effective sampling scheme for physical verification of stocks of wheat & rice in their godowns. In phase I of the study the scope was identified and in phase II a detailed survey was carried out to develop a cost effective, simple and statistically sound sampling scheme and related procedure which FCI can adopt for physical verifications of stocks on permanent basis.

Forecasting of Demand for Ball and T/R Bearings in India and Assessment of Customer Satisfaction at N.E.I. Jaipur

National Engineering Industries (NEI), Jaipur was interested in estimating total monthly demand for bearings of different types and sizes, and this exercise addresses one particular sub segment of original

applications of bearings, namely the demand for bearings of different types and sizes that may arise from the manufacturers of passenger cars.

Development of Generic algorithm for path optimization in PCB manufacturing at R Systems International Ltd, Noida

The problem of component allocation and sequencing of placements/insertions of jobs optimally, to decide the mode (gang, individual or simultaneous) of pick up and the number to be picked up in each pick up trip of the head/heads, to decide the types of nozzles that should be fitted to the head/heads in the beginning and how and when the nozzles should be changed optimally and to schedule the use of the shuttle carrier optimally if it is present, may be formulated or modeled as a nonlinear integer programming problem. The computational complexity of solving such problem is NP-complete/hard. Path optimization heuristics have been proposed for the specified machines where some common subroutines may be used along with some problem specific methods to take care of the machine specific constraints.

Proficiency Testing Programme on Egg Powder Testing at NABL, Department of Science & Technology, Govt. of India

National Accreditation Board for Testing and Calibration (NABL) has been participating regularly in the proficiency testing programme organized by Asia Pacific Laboratory Accreditation Cooperation (APLAC). Recently NABL has received a proposal from APLAC to organise Proficiency testing programme on egg Powder Testing on behalf of APLAC. As a part of the programme NABL will receive proficiency testing data from 150 laboratories of about 35 countries covering European Accreditation bodies as well as APLAC members Accreditation bodies. Statistical analysis of the data for comparison of lab performances and identifying the outlier labs has been assigned to ISI as a project.

Project Guidance

Consultancy / project guidance was provided to the following organizations:

- Consultancy / Project guidance provided to Modern Food Industries Pvt. Ltd., New Delhi.
- Optimization of time for exchanging information through e-mail, at GE Capital Services India.
- Minimization of Export consumption for mechanically assembled aluminum radiators manufacturing, at Climate systems India Ltd. Bhiwadi, Rajsthan.
- Development of central procedure for small process shift in Header-to-Header height, at Climate systems India Ltd., Bhiwadi, Rajsthan.
- Consultancy / project guidance provided to Samtel Group of Industries in six sigma implementation and project work.
- Project guidance provided to Maruti Udyog Limited on Measurement of Customer Satisfaction Index.
- Project guidance provided to International Electronic Devices, Limited, Ghaziabad.
- Project guidance provided to Orient Fans, Faridabad.

Training Projects

1. 2-day Training Programme on Statistical Methods	May 1-2, 2001	NTPC, Dadri
2. Six-Sigma Green BeltTraining Programme	Aug. 30– Sep. 1, 2001	Samtel Group of Industries
3. Six-Sigma (IV Module) Black Belt	May 14-16, 2001	Samtel Group of Industries

Training Programme		
4. Two-day Training Programme on Statistical Tools for Quality and Productivity Improvement	October 19 – 20, 2001	Mahatma Gandhi State Inst. of Public Admn., Chandigarh
5. Three-day Training Programme on Process Analysis and Design of Experiments using STATISTICA	September 26-28, 2001	Indian Oil Corporation Limited, Faridabad
6. Six Sigma Champion Training Programme	September 14-17, 2001	Samtel Group of Industries
7. Six Sigma Green belt Refresher Training Programme	February 25, 2002	Samtel Group of Industries
8. Two awareness Programmes on Six Sigma	December 24, 2001 and February 25, 2002	Samtel colour Limited and Samtel Electron Devices
9. Two-day Trainning Programme on Six Sigma	February 25-26, 2002	Power Grid corporation of India Limited, New Delhi
10. One-day Trainning Programme on Neural Network using Statistica	October 11, 2001	Indian Oil Corporation Limited, Faridabad
11. Six Sigma, Green Belt Trainning Programme	March 7-9, 2002	Samtel Electronic Devices, Parwanoo

Hyderabad Unit

Research Activities

Linear Models

Foundations of Linear Inference based on linear sufficiency and linear first order ancillarity (linear zero functions) have been studied.

Regression Analysis

Diagnostics for detecting collinearity are being critically evaluated and some new measures are being developed.

Study of non-symmetric p.s.d. and almost definite matrices

Non-symmetric p.s.d. and almost definite matrices and their applications to semi-definite linear complementarity problems have been studied. Some characterizations of the non-symmetric p.s.d. matrices have been obtained.

Process Capability

Graphical methods for studying process capability are being developed which are expected to bridge the gap between the theoreticians and the practitioners, particularly in the industry in this area.

Modelling measurement error

Research Continued on this topic.

Projects Undertaken

ISO 9000 certification for M/s SEW Constructions

The organisation obtained ISO 9001 certificate.

ISO 9000 certification for M/s Prasad & Co

The organisation obtained ISO 9001 certificate.

Training Projects

Title	Date	Organisation
A. Training (In-company prog.)		
1. Six Sigma Quality	21-22 June, 2001	Code Links Data Services Ltd
2. Tools & Techniques for Six Sigma Quality	12-14 July, 2001	Vetrotex India Ltd
3. Green belt training Prog. on Six Sigma	16-19 July, 2001	Satyam Software Ltd
4. ISO – 9000 (six programmes)	April-August 2001	SEW Constructions
5. ISO – 9000 (four programmes)	May-August 2001	Prasad & Co.
6. Six Sigma Management Briefing	15 October 2001	Reliance Industries Limited
7. Module - I for Six Sigma Black Belts	6-9 November, 2001	Reliance Industries Limited
8. Module – II for Six Sigma Black Belts	11-14 Dec., 2001	Reliance Industries Limited
9. Green Belt Training Prog. on Six Sigma	19 November 2001	Satyam Computer Services Ltd
10. Statistical Process Control	16 February 2002	Hyderabad Industries Ltd.
11. Six Sigma	2 days	Coromandel Fertilizers
12. Mathematical and Statistical Tools	37 lectures	GVK Bio
B. Training programmes		
1. Six Sigma Quality	1-2 June, 2001	45 executives from various organisations attended.
2. Quality Function Deployment	11-12 October, 2001	10 executives from various organisations attended.
3. Statistical Process Control with focus on Six Sigma Quality	6-8 November, 2001	7 executives from various organisations attended.

Project guidance is being provided to the following organisations :

Prasad & Co.(ISO 9000), SEW Constructions (ISO 9000), Code Links Data Systems Ltd (Six Sigma), Intelli Group (Six Sigma), Balaji Rail Road Systems (Six Sigma), Nuclear Fuel Complex (Six Sigma) QS 9000, Vijayjyot Seats Ltd., Halol (QS 9000),Vetrotex India Ltd. (Six Sigma), ITC-ILTD, Chirala, Anaparthi Div. (Six Sigma), Midhani Ltd. (Process Evaluation), Assam Carbon Products Ltd. (ISO 9000/SQC Implementation), Hyderabad Industries Ltd. (ISO 9000 Audit).

Kolkata Unit

Projects Undertaken

Externally Funded

Reduction in variation of weight of packed biscuits

Major sources of the problem were identified and a process control system was established to take care of different process parameters at all the stages of mixing to baking and packing. This resulted in reduction of underweight packets from 22.2% to 4.1%, overweight packets from 8.5% to 5.9% and count variation from 33-38 to 34-36.

ISO 9000 for Surya Tobacco, Nepal

The Company has been awarded the certificate in October 2001.

Estimation Models

The models have been developed for the software company : Infosys.

Assessment of Health Care System in Peerless Hospital

An in-house routine survey methodology has been suggested in place of existing "Exit Opinion Survey" due to difficulty in administering the latter. A questionnaire was framed based on three dimensions of service quality, viz., physical, interactive and corporate, containing questions of dichotomous, open-ended and multiple choice type. Suitable sampling fractions have been developed from among monthly discharged patients, nurses and doctors. This in-house survey methodology has been incorporated in their ISO 9000 Quality management System.

Consumer Feedback Survey in Coal India Ltd. (CIL)

An all-India assignment was taken up to assess the perception of non-core sector consumers in respect of CIL as supplier and their opinion about a proposed change in the system of sale of coal. Draft form of the questionnaire designed was validated by sending it to a small sample of consumers, randomly selected from three high-consumption and easily accessible states, viz. Bengal, Bihar and 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. Data obtained were analysed using appropriate non-parametric statistical techniques and the report was submitted.

Minimisation of cutting loss in the manufacturing of Hosepipes

At Jayasree Textiles, Rishra, process variability present at the different stages, namely, rubber cutting, jacket cutting, extrusion and vulcanisation were suitably measured. Finally, optimum jacket length was determined to minimise the cutting loss of hosepipes at the final stage.

Evaluation of bleaching performance for flax fiber

The project was carried out at Jayasree Textiles, Rishra. Before wet spinning, flax fibers are treated with bleaching. The performance of bleaching is evaluated by the whiteness of the flax in terms of three indices, viz. white index, yellow index, and red index. For the evaluation of on-line process performance, individual as well as combined monitoring schemes for the three indices have been introduced.

Reduction of reprocessing at Fabric Dye House

The project was carried out at Jayasree Textiles, Rishra. To start with, vital areas of reprocessing were selected. Subsequently, the reasons for reprocessing of those areas were identified. Appropriate corrective actions were taken to reduce the reprocessing and to minimise the difference in performance measure between laboratory and the plant.

Determination of monthly service times for software maintenance

The project was carried out at Skytech Solution Pvt. Ltd. The objective of the study was to get an estimate of the monthly service time required for the maintenance of a software project under AMC so that the allocation of the expertise along with the time required for maintenance could be decided beforehand. A simulation model was developed to get the number of maintenance requests and the corresponding service time for a given month.

Improvement of Process Capability Baselines (PCB)

The project was carried out at Infosys Ltd., Bangalore.

Process Capability Baselines (PCB) are used by all software organisations as standards for planning and control of software projects. The PCB provides organisational standards for productivity and defect rates. Based on these values and the estimated size, the Product Manager estimates the effort required and decides about rereview, retests and product release. In this project, the productivity and defect rates of different software projects were grouped. On the basis of the analysis, major stratification factors like size and code domination were arrived at and different PCBs were developed for various combinations of size and code domination. The resulting PCBs fitted the project scenario much better and were widely accepted

Optimization of Software Maintenance Process

Many software maintenance contracts have an associated service level agreement which requires the vendor to attend to and rectify a reported problem within a predetermined time-frame. In these cases, estimating the number of persons required for bug-fixing is of utmost importance.The maintenance process was looked at as a queuing system where bugs arrived at random and needed to be serviced by programmers. The inter-arrival time distribution was found to follow Gamma distribution with reasonable accuracy. The service time, however, had to be stratified since two distinct distributions were found to exist for simple and complex tasks. The optimal number of programmers required was obtained using simulation software which was developed to implement this method in general

Control of Software Projects

The project was carried out at Novell Software, Bangalore. Tracking and controlling software projects is an important issue for all software organisations. In this project the control was introduced by using the Work Breakdown Structure (WBS) prepared at the project planning stage. The WBS identifies the elementary activities and the estimated times are also provided. The variation between estimated and the actual times were analysed On the basis of this analysis, specific project groups and phases were identified. Control charts were then implemented to keep track of the variability and to enable the Managers to identify "problematic" tasks. Simple forecasting models were also developed to estimate the remaining effort and schedule given the current status Comprehensive Excel & VB based tool is being developed jointly by Kolkata and Bangalore SQC Units for smooth implementation of the project.

Reducing Cone-weight Variation

The objective of the study done at Jaysree Textiles was to control the variation of yarn length in the form of cones by controlling cone weight variation, a system that is prevalent in the textile industry. Through application of statistical techniques, significant sources of variation in cone weight could be identified. The implementation of the relevant recommendations resulted in reduction in yarn loss at the warping stage from around 23% to 1.75% resulting in higher productivity, better warping quality and reduced customer complaints.

Determining Optimum Working Level at Wool Combing at Jaysree Textiles

Wool fibres generate static electrical charges during processing because of friction with the metallic parts of the machinery. Unless this charge is neutralised by a media that is a conductor of electricity, the fibres tend to scatter in all directions causing lapping and fibre breakage. The best conducting material for this purpose is water present in the wool. The study helped to arrive at the optimum operating conditions including departmental relative humidity and temperature that would maximise actual Hauteur or fibre length and top yield. The expected financial gain is Rs.14.65 lakhs per annum.

Training Projects

36 inplant training programmes were conducted in different organisations and were attended by 655 participants. In addition, three training programmes were conducted jointly with ERTL (East) on Software Metrics, Testing and Project management.

Mumbai Unit

Projects Undertaken

Six Sigma Implementation at M/s Reliance Industries Ltd., Patalganga

The unit has taken up the challenging task of implementing Six Sigma in this organisation. Top Management was trained in this philosophy. Programmes were conducted on Six Sigma Champions, Black belt and Green belt. A total of 132 managers at different levels were trained. 16 projects directly linked to business

were identified and completed resulting in a saving of Rs. 475 lakhs. The second phase of implementation is continuing.

Six Sigma Implementation at M/s Larsen & Toubro Ltd., Electrical Business Group

The unit has taken up the task of implementing Six Sigma in this organisation also. Top Management was trained in this philosophy. Programmes were conducted on Six Sigma Champions, Black belt and Green belt. A total of 57 managers at different levels were trained. 17 projects directly linked to business were identified and completed resulting in a saving of Rs. 115 lakhs. The second phase of implementation is continuing.

ISO 9000 & TQM Implementation

Six Sigma Black belt training at M/s Reliance Industries Limited for 50 executives. (16 days)
Six Sigma Champions training at M/s Reliance Industries Limited for 20 executives (5 days)
Six Sigma Black belt training at M/s Larsen & Toubro Limited for 33 executives (16 days)
Six Sigma Champions training at M/s Larsen & Toubro Limited for 20 executives. (5 days)
SPC training at M/s Classic Industries and M/s WIMCO limited covering 30 executives. (3 days)
Design of Experiments training at M/s Mahindra & Mahindra covering 80 executives. (2 days each, 4 programmes)

T & P Unit

Research Activities

Multivariate Simulation for Cost Effective Decision Making

Applied research on using multivariate simulation model for cost effective managerial decision making and quality improvement was undertaken. It was adequately demonstrated that use of mathematical modeling and simulation could aid such decisions under a probabilistic set up that represents the real life environment.

Projects Undertaken

A. Externally Funded Projects

Control of percent alpha phase and percent LOM in Alumina at Calcination (Indal, Belgaum)

To ensure greater yield of metallic Aluminium in smelter, it was required to control the percent α - phase and LOM content of calcined Alumina well below 20 and 1 respectively. The interrelation of 17 process variables of calcination and their effects (individual and selected interactions) on α -phase and LOM content in Alumina were studied using multiple regression techniques. The key variables, which predominantly influenced α and LOM were identified and their working zones were found. Stepwise working algorithms were developed for the Direct Control System (DCS) based on regression models to control the key variables (Stack draft, Hydrate feed, Oil pressure) within their stipulated ranges. On implementation, there was marked improvement in the quality of Alumina with respect to its α - phase + LOM content.

Identifying the Optimum Setting for maximum yield and purity of a specified brand of pesticide. (ECS Ltd., Mumbai)

In order to improve the yield of a pesticide with high purity and its productivity (i.e., minimum reaction time), a series of experiments were performed using orthogonal array and response surface designs involving important variables like pot temperature, Molar ratio of MMCA compound, rate of addition of MMCA, Molar ratio of $NaHCO_3$, Molar ratio of TBAB, Solvent ratio and agitation speed with the response variables: yield, purity and reaction time. The key variables influencing the yield, purity and reaction time of the pesticide were identified and using the analysis of the response surfaces, a satisfactory solution was obtained based on trade off

which improved yield and purity of the pesticide with reduced reaction time. Confirmatory trial runs were performed which validated the process conditions for the solution. Implementation of the recommended process conditions is under way.

Developing an appropriate sampling plan for estimating non-cane material in cane consignment to sugar mills (ECS Ltd., Mumbai)

Presence of non-cane material (leaves, top portions of sugar cane sticks, etc.) in sugarcane has an adverse effect on the yield (sugar). This necessitated proper estimation of % non-cane material in sugar cane consignments arriving in a sugar mill. An appropriate sampling scheme was developed to estimate % non-cane materials (modelled with a log normal distribution) in sugar cane consignments to predict the level with pre-specified precision having taken into account the variation between different varieties of cane sugar.

Developing a customer satisfaction measurement index and identifying Key Satisfiers/dissatisfiers and major product/service features through customer survey (ECS Ltd., Mumbai - on going).

The project aimed at developing customer satisfaction index for both external and internal customers of a giant Petrochemical factory. The first part of the project concerning development of a customer satisfaction index of the internal customers (workers and employees) was taken up. The parameters to be considered (such as personnel management scheme, adjustment of individual goals with company goal, transparency, work ethics and culture, reward and recognition system, etc.) were identified. Detailed questionnaire asking for responses on a 5-point scale was also prepared and circulated among the employees. The data collection and analysis with multivariate techniques is being done to identify key satisfiers and dissatisfiers.

Project Guidance

Consultancy projects were taken up during the year for the following organisations:

a. Indal, Belgaum
b. Tata Metaliks Ltd., Kharagpur
c. Eicher Consultancy Services Ltd., Mumbai

Details of In-plant training programmes organised during the year are given below :

Title	Dates	Venue	No. of participants
Training programme on 'Response Surface Methodology' for the executives	12-13 October, 2001	ECS Ltd., Bangalore	30
Corporate Training on Applied Statistics	19-21 November, 2001	M. N. Dastur & Co. Ltd., Kolkata	24

B. Internally Funded Projects

Quality mission Project

The present number of Quality Mission Executives (QME) working in the project is 5. While 5 QMEs were recruited during the year, 8 had left. The QMEs served 22 organisations and organised 20 training programmes. Collaboration with UNIDO in their cluster development programme is being successfully maintained with appreciation from UNIDO. The project has generated an income of Rs.7.54 lakhs.

Specialist Development Programme (SDP)

The SDP Cell trained 5 fellows of 2001-2002 batch and 4 fellows of 2002-2003 batch. Theoretical training was given for a month, covering topics of Quality management, Taguchi Methods, ISO 9001:2000, QS 9000, Multivariate Data Analysis and case studies. The remaining period of 11 months was devoted to live

project studies under the supervision of the faculty of the Division in different Units. 20 project reports were submitted to organisations where the projects were taken up.

Newsletter

The Division continued to publish the quarterly newsletter covering important events and activities of the Division. The newsletter publishes articles in Quality Management and related areas, book reviews and significant contributions in the field of Quality.

Cell for Promotion of Service Abroad

ISO 9001:1994 Implementation at Shinepukur Ceramics Ltd., Dhaka, Bangladesh

The company is an export-oriented ceramic tableware manufacturing organisation. Necessary inputs were provided. The company was certified by DNV for ISO 9001-1994 in August 2001.

ISO 9001: 2000 Implementation at Shinepukur Ceramics, Bangladesh

Subsequent to the certification obtained for ISO9001:1994, the organisation wanted to upgrade their system with built-in element of customer focus and continual improvement. Accordingly necessary inputs were provided. The organisation was awarded the certificate of ISO 9001:2000 standard as one of the first few organisations in Bangladesh.

Training Programme on Steps and Techniques of Quality

A two-day programme was organised with support from Management System and Services, Dhaka.

Training Programme on SPC

A one-day programme on SPC was conducted for the executives of Opsonin Pharmaceutical Ltd. on 19 September 2001.

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 of "Associateship in Documentation and Information Science" (ADIS). This award is recognised by the Govt. of India and several universities, as equivalent to 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 members of the DRTC faculty were engaged during the period, are: (i) Study of various methods of knowledge representation, such as, semantic nets, frames, and predicate calculus, etc., (ii) Application of the "Modern scientific management techniques to the planning and management of information system, centers and services, (iii) Study of Information technology and its applications, including library automation, Internet applications, digital libraries, etc. and (iv) Development of bibliometric and scientometric measures for evaluating the use of library and information services and scientific output respectively.

Library (Kolkata)

With the addition of 1348 books and 1237 bound volume of journals to the stock, the total collection of the Library rose to 2,18,295.