2004-2005

Annual Report

Indian Statistical Institute

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16 Prof. Deb Kumar Bose, former Chairman, West Bengal Pollution Control Board, Kolkata.
17 Prof. Jogabrata Roy, Professor Emeritus, Indian Statistical Institute, Kolkata.
18 Prof. Shyam Mata (former Head, Plant Chemistry Unit, Indian Statistical Institute), New Delhi

Elected representatives of the employees of the Institute

19 Shri Sandip Mitra, Representative of the Scientific Workers.
20 Shri Probir Chattoraj, Representative of the Non-Scientific Workers.

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22 Prof. Tapas Samanta, Professor-in-Charge, Applied Statistics Division.
23 Prof. Amita Majumder, Professor-in-Charge, Social Sciences Division.
24 Prof. Himadri Pai Mazumdar, Professor-in-Charge, Physics and Earth Sciences Division.
25 Prof. Joydev Chattopadhyay, Professor-in-Charge, Biological Sciences Division.
26 Prof. Malay Kumar Kundu, Professor-in-Charge, Computer and Communication Sciences Division.
27. Prof. P. Bhimasankaram, Head, Statistical Quality Control and Operations Research Division.
28 Prof. R. L. Karandikar, Head, Delhi Centre.
29 Prof. I. K. Ravichandra Rao, Head, Bangalore Centre.
30 Dr. Sujit Kumar Majumdar, Dean of Studies.

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INDIAN STATISTICAL INSTITUTE

Annual Report
April 2004 – March 2005

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INDIAN STATISTICAL INSTITUTE
SEVENTY THIRD ANNUAL REPORT
April 2004 - March 2005

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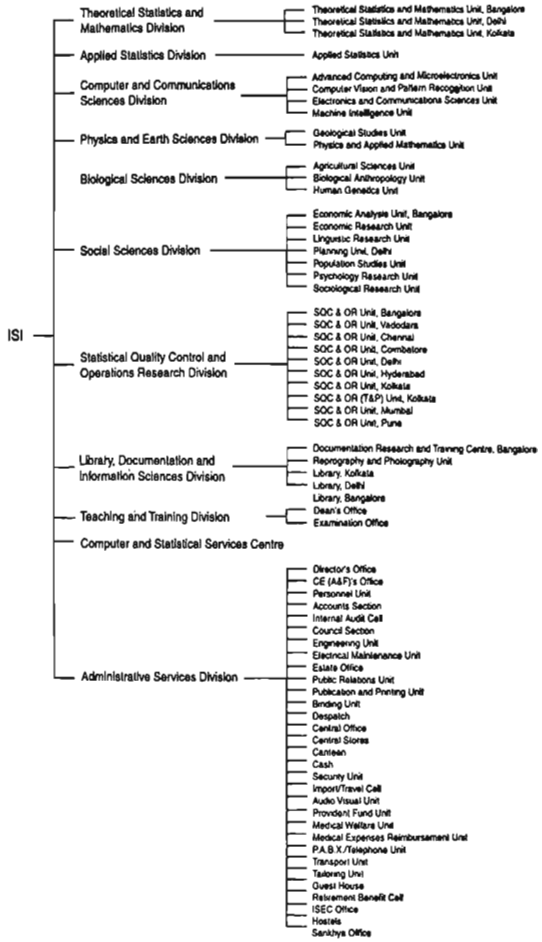

Organization of Divisons and Units of ISI

A BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early nineteen twenties through the pioneering initiative of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological Survey of India) 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 des ign, development and fabrication of a fully transistorized digital computer, called ISIJU-1 which was commissioned in 1966 by Shri M.C. Chagla, the then Minister of Education, Government of India. The Institute has regularly upgraded its computing facilities and currently has a network of high-performance computers and a large bandwidth connection to the Internet.

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

The Indian Statistical Institute Act of 1959 was amended by the Parliament in September 1995 to empower the Institute to award Degrees/Diplomas not only in Statistics but also in Mathematics, Quantitative Economics, Computer Science and such other subjects related to Statistics as may be determined by the Institute from time to time. Following the amendment, a Master of Science course in Quantitative Economics and an undergraduate course, B. Math. (Honours) in Mathematics, have been added to the teaching and training programmes.

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

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

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

(i) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to problems of planning for national development and social welfare;

(ii) to undertake research in various fields of natural and social sciences with a view to the mutual development of statistics and these sciences;

(iii) to provide for, and undertake, the collection of information, investigations, projects, and operational research for purposes of planning and the improvement of efficiency of management and production, and

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

The Units of academic, scientific, administrative and service activities of the Institute were regrouped into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 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 2004-2005 has seen in the Indian Statistical Institute, like other years, some of its faculty gather honours and awards – Professors Arup Bose and Probal Choudhury of Theoretical Statistics and Mathematics Unit, Kolkata received the Shanti Swarup Bhatnagar award and the C.R. Rao award respectively, Professors R.B. Bapat and R. Bhatia of Theoretical Statistics and Mathematics Unit in Delhi Centre have been elected Fellows of the Indian National Science Academy. Also, Professor N.R. Pal of Electronics & Communication Sciences Unit, Kolkata has been elected a Fellow of I.E.E.E. and Professor Bhabatosh Chanda of the same unit, a Fellow of I.N.A.E. Amongst the younger faculty, Dr. Mahuya Datta of Theoretical Statistics and Mathematics Unit in Kolkata has been made an associate of I.C.T.P., Trieste, Italy. All of them deserve our hearty congratulations.

The first phase of construction in the campus at the headquarters has been completed and various academic units have moved into the New Academic Building – Phase I, while the new Boys' and Girls' hostels have been occupied. The second phase of constructions is on the way, with the work on a modern substation nearing completion, that on the transport and stores' building having started and a D-type quarters in the planning stage.

It has been an experience of a lifetime for me as the Director of this great institution – there have been moments of despair as well as of elation as I have tried my best to guide the institute through the unavoidable demands of change. The work is not finished, in fact it cannot be finished because change is the source of dynamism of any living institution. I can leave with some satisfaction that despite difficulties, I have, in a small way, been a catalyst of change.

I am grateful to all the workers of this institute for having helped me in my efforts – some directly, the rest indirectly. I implore them to continue the good work so that this institute can forge ahead to attain greater prosperity and glory.

31. 03. 2005 K. B. Sinha

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

1. TEACHING AND TRAINING

Degree and Other Courses

A brief account of teaching and training activities of the Teaching and Training Division during the academic session 2004-2005 is given below.

During the academic session 2004-2005 a total of 10,959 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. Math; Master of Science (M.S.) in Quantitative Economics; M. Tech. in Computer Science; M. Tech. in Quality, Reliability and Operations Research; Associateship in Documentation & Information Science; Research Fellowships in Statistics; Mathematics; Economics; Computer and Communication Sciences; Physics and Applied Mathematics; Sociology; Demography; Geology; Agriculture; Anthropology and Human Genetics and Library and Information Science. Admission tests were conducted at 24 different centres all over the country. A total of 8149 candidates finally appeared for admission tests and a total of 501 candidates qualified in the written tests, and were called for interviews. Based on the performance in the written tests, interview and the academic records, 195 candidates were offered admission to various courses during the academic session under review.

The annual examinations for all the regular courses offered during 2003-2004 were held during April-May 2004. The 2004-05 academic session commenced on 19 July 2004.

The number of existing candidates in different degree, diploma, associateship courses, Junior/Senior Research Fellowship and Research Associateship during 2004-2005 and the number of students who passed in the annual examination in 2004, are given in Table 1. The list of candidates who were awarded Ph. D degrees by the Institute, is given in Table 2. The list of candidates who have been awarded Ph. D. degrees by academic bodies other than ISI, is given in Table 3.

Till March 2005, 228 trainees of Engineering and Technology courses from the following Universities/Institutions received two weeks/six weeks/two months/four months and six months Project training in different Units of the Institute, viz., ECSU, CVPR, CSSC, MIU, ACMU, ASU, SQC-OR T&P Unit and SMU, under the guidance of different faculty of the Institute : Techno India - Kolkata, JIS College of Engineering - Kolkata, Bankura Unnayani Institute of Engineering, University of Burdwan, IIT Roorkee, Narula Institute of Technology - Kolkata, K.S.R. College of Arts and Science Tiruchengode, Seemanta Engineering College - Mayerbhanj, Heritage Institute of Technology, IIT Chennai, Sanjeevani College of Para-Medical & Applied Technologies, Sri Jagadguru Chandrashekaranatha Swamiji Institute of Technology, Asansol Engineering College, College of Engineering & Management - Kolaghat, Haldia Institute of Technology, The Institute of Computer Engineers (INDIA), IIT Kanpur, Jadavpur University, Institute of Engineering & Management - Salt Lake, Calcutta, IIT Guwahati, Indira Gandhi National Open University, Sikkim Manipal Institute of Technology, B. P. Poddar Institute of Information & Technology- Kolkata, College of Leather Technology (Govt. of W.B.), RCC Institute of Information & Technology, Vellore Institute of Technology, College of Ceramic Technology, Bengal Institute of Technology, Regional Engineering College - Durgapur, Dumkal Institute of Engineering & Technology, Netaji Subhash Engineering College, Orissa University of Agriculture & Technology, Electronics Research & Development Centre of India (Calcutta Unit), Vidyasagar University, University of North Bengal, MCKV Institute of Technology, and IIT Kharagpur.

Number of students who passed in different courses (2004) and number of existing students/fellows (2004-2005)

Sl. No.	Course	Number of Students	
		Passed in the Annual Exam. in 2004	Existing numbers in 2004-05
Degree			
01.	Bachelor of Statistics with Hons. (B.Stat.(Hons.))		
	1st year	28	28
	2nd year	22	29*
	3rd year	25	20+
02.	Bachelor of Mathematics with Hons. (B.Math.(Hons.))		
	1st year	9	13
	2nd year	12	10*
	3rd year	6	13*
03.	Master of Mathematics (M.Math.)		
	1st year	7	3
	2nd year	-	7
04.	Master of Statistics (M.Stat.)		
	1st year	37	43
	2nd year	29	36++
05.	Master of Science in Quantitative Economics(M.S.(QE))		
	1st year	20	19
	2nd year	19	20
06.	M.Tech. in Computer Science		
	1st year	24	18
	2nd year	15	22**
07.	M.Tech. in Quality, Reliability & Operations research		
	1st year	13	10
	2nd year	12	13
08.	Junior & Senior Research fellows and Research Associates in different disciplines	12***	102
Diploma			
09	Junior Diploma in Statistics (JDS)	5	-
	Senior Diploma in Statistics (SDS)	3	-
Associateship			
10.	Associateship in Documentation and Information Science (Bangalore)		
	1st year	5	4
	2nd year	6	5
	Grand Total	**308**	**415**

* The number increased by 1 since a student has been repeating.
** Three students discontinued in 2nd year and one student has been repeating in 2nd year.
*** Awarded Ph. D. degree in the Convocation (2005).
\+ Two students discontinued due to bad performance.
++ One student discontinued.

Ph.D. Degrees Awarded

A) Ph.D. Degrees awarded by the Institute during the 39th Convocation held on 18 March 2005

Sl. No.	Name of the Fellow	Title of the Thesis	University/ Institute	Name of Supervisor
1.	D. Sampangi Raman	Some Contributions to Semidefinite Linear Complementarity Problem	ISI	T. Parthasarathy Stat-Math Unit ISI, Delhi
2.	Anil Kumar Ghosh	Some Nonparametric and Semiparametric Methods for Discriminant Analysis.	ISI	Probal Chaudhuri Stat-Math Unit, ISI, Kolkata
3.	Sudipta Dutta	Intersection Properties of Balls in Banach Spaces and Related Topics	ISI	Pradipta Bandyopadhyay Stat-Math Unit ISI, Kolkata
4.	Kishan Chand Gupta	Cryptographic and Combinatorial Properties of Boolean Functions and S-Boxes	ISI	Palash Sarkar Applied Statistics Unit, ISI, Kolkata
5.	Arpita Dhar	Essays on Dynamic Disequilibrium Models	ISI	Robin Mukherjee Economic Research Unit, ISI, Kolkata
6.	Sasthi Charan Ghosh	Efficient Channel Assignment Techniques in Cellular Mobile Networks	ISI	Bhabani P. Sinha AdvancedComputing and Microelectronics Unit, ISI, Kolkata.
7.	Shamindra Kumar Ghosh	On Planar Algebras and Representations of the Annular Category over a Planar Algebra	ISI	V. S. Sunder The Institute of Mathematical Sciences, Chennai
8.	Subhadip Ghosh	Trade and Foreign Direct Investment between Developed and Developing Countries : Their Impacts on Trading Bloc Formation, Firm Sustainability and Income Distribution.	ISI	Satya P. Das Planning Unit, ISI, Delhi
9.	Pradeep Kumar Mishra	Studies on Efficient and Secure Implementation of Elliptic and Hyperelliptic Curve Cryptosystems.	ISI	Palash Sarkar Applied Statistics Unit, ISI, Kolkata
10.	Avishek Adhikari	Applications of Combinatorial Structures in Secret Sharing and Visual Cryptography.	ISI	Bimal Roy Applied Statistics Unit, ISI, Kolkata.

11.	Subhadip Bandyopadhyay	Classification With Unbalanced Training Sample From Correlated Populations	ISI	Shibdas Bandyopadhyay Applied Statistics Unit, ISI, Kolkata.
12.	Santanu Dey	Standard Dilations of Tuples and Representations of certain C^* - Algebras	ISI	B. V. Rajarama Bhatt Stat-Math Unit, ISI, Bangalore

B) Ph. D. Degree awarded by Academic Bodies other than Indian Statistical Institute

Sl. No.	Name of the Fellow	Title of the Thesis	University	Name of Supervisor
1	Paramita Nandy (Datta)	Certain Aspects of Eco-Physiology and Anatomical Investigations in some Mangroves of Sundarbans, West Bengal	University of Calcutta	M. Ghose Ag.S.U., ISI
2.	Priyanka Chaudhuri (Majumdar)	Monitoring Cellulolytic Microflora from different Ecological niches with special reference to Saccharification and Biodegradation	University of Calcutta	Sunanda Chanda Ag.S.U., ISI
3.	Samaresh Pal	Role of Viral Infection on Predator – prey system with special emphasis on phytoplankton zooplankton system – model based study	Jadavpur University	Joydev Chattopadhyay Ag.S.U., ISI
4.	Nilabja Sikdar	Genomic polymorphisms at Drug Metabolizing Loci : Relationships to oral squamous cell carcinoma & precancerous lesion and frequencies among ethnic populations of India	Jadavpur University	Bidyut Roy HGU, ISI
5.	Sushmita Ghosh (nee De)	Genetic Algorithms : Some new operators and applications to Connectionist Object Extraction	Jadavpur University	Sankar K. Pal MIU, ISI

INTERNATIONAL STATISTICAL EDUCATION CENTRE (ISEC)

The Centre was established in 1950 and is operated jointly by the International Statistical Institute, Netherlands and the Indian Statistical Institute, under the auspices of UNESCO and the Government of India. It functions under a joint Board of Directors. The Directors represent International Statistical Institute, Indian Statistical Institute and the Government of India. Prof. P.C. Mahalanobis was the

Chairman of the Board of Directors since the inception of the Centre in 1950 until his death in 1972. Since then National Professor C.R. Rao, FRS, has been the Chairman of the Board.

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

The announcement of the 58th term ISEC Regular Course was issued and prospectus and application forms were distributed by the Centre at Kolkata on behalf of the Permanent Office of the International Statistical Institute at Voorburg, Netherlands. A number of prospectus and application forms were also distributed through Government of India. The governments of different countries were invited to nominate suitable candidates for training at the Centre. The Centre also requested the Indian Missions in different countries to extend their co-operation in receiving and forwarding applications both for admission and for fellowship.

A total of 13 candidates had been offered admission to the 58th term of the Regular Course of this Centre. Of the 13 candidates, 7 trainees were supported by fellowship awarded by Government of India under the Technical Co-operation Scheme of the Colombo Plan (TCS of Colombo Plan), 4 trainees received grant from India Technical and Economic Cooperation (ITEC) or Special Commonwealth African Assistance Plan (SCAAP). The other two trainees were sponsored by the Central Bank of Iran. The trainees from Iran have discontinued the course due to health reason.

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

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

The Regular Course of the fifty eighth term started on 1 June 2004. English is the medium of instruction at the Centre. The training included lectures, laboratory work, project work and assignments. The first four months at Kolkata were devoted to general statistical training including training in mathematics, electronic data processing, probability theory, descriptive statistics, sample survey techniques, statistical methods and economic statistics. These courses were compulsory for all students. Further training for six weeks in Official Statistics was conducted by the Central Statistical Organization, Government of India, New Delhi. This was followed by eight-week training at Kolkata in general statistical methods for optional subjects during middle of November, 2004 to middle of January, 2005. In this phase the trainees pursued some of the courses (at least four, of which Data Processing II was compulsory) studied by them during the first four months, more vigorously. Finally, from middle of January to March 2005 the trainees specialized in particular fields of applied statistics like demography, data processing, large-scale sample surveys and Economic Planning. All these Specialization Courses expect Economic Planning were held in Kolkata. The Specialization Course on Economic Planning was held in Bangalore in the Economic Analysis Unit of Indian Statistical Institute.

The teachers of this centre at Kolkata were mostly drawn from the various units of the Headquarters of the Indian Statistical Institute while Statistical Officers of the Govt. of India took part in the teaching programme of the six-week course in Official Statistics organized by the Department of Statistics, Government of India, New Delhi. The teachers of Economic Analysis Unit at Bangalore Centre of ISI taught the specialization course on Economic Planning.

The valedictory ceremony for the ISEC Regular Course was held on 24 March 2005. Professor S.C. Bagchi, Deputy Director, Indian Statistical Institute presided over the meeting and delivered the

welcome address. Professor Nikhilesh Bhattacharya, Visiting Professor, Indian Statistical Institute, was the Chief Guest and delivered the valedictory address.

Professional Examination in Statistics

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

(I) **Junior Diploma in Statistics**
(II) **Senior Diploma in Statistics**

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

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

The total number of candidates and their results from January 2004 to December 2004 term of the examinations are shown below. The 50th Term Professional examinations were held during December 13 to December 24, 2004 and the result was published on January 4, 2005. This is the last term as the examinations are being discontinued.

EXAMINATION		Registered			
		Jan. 2004	May 2004	Sept. 2004	Dec. 2004
1.	*Junior Diploma in Statistics*	19	10	04	02
2.	*Senior Diploma in Statistics*	09	04	03	02

EXAMINATION		Appeared			
		Jan. 2004	May 2004	Sept. 2004	Dec. 2004
1.	*Junior Diploma in Statistics*	09	10	02	01
2.	*Senior Diploma in Statistics*	05	04	02	02

EXAMINATION		Passed*			
		Jan. 2004	May 2004	Sept. 2004	Dec. 2004
1.	*Junior Diploma in Statistics*	04	03	02	01
2.	*Senior Diploma in Statistics*	04	01	02	02

** Passed in one or more papers only, not necessarily completed the examination.*

During the period under review, three candidates cleared SDS Exam. and five candidates cleared JDS Exam. and they were awarded Diplomas in the 39th Convocation.

The cumulative total number of candidates who have qualified for the award of the Diplomas in the Professional Examinations in Statistics including the result of December 2004 term is 311.

2. Convocation

The 39th Convocation of the Indian Statistical Institute was held on 18 March 2005 at 3:50 p.m. It started with Vedic Hymn by ISI Club, followed by welcome address by Prof. M.G.K. Menon, President, ISI, and report by Prof. K.B. Sinha, Director, ISI. This was followed by Convocation Address by His Excellency Gopal Krishna Gandhi, Governor of West Bengal. Then, the degrees and diplomas were awarded to students by Prof. M.G.K. Menon, President, ISI. The Convocation was closed by Prof. M.G. K. Menon, President, ISI, after a vote of thanks by Dr. S.K. Majumdar, Dean of Studies, ISI.

Numbers of candidates who were awarded obtained degrees/diplomas in Thirtyninth Convocation of the Institute, held on 18 March 2005, is provided below:

	Degree/Diploma	Number of Candidates
1.	Doctor of Philosophy (Ph.D.)	12
2.	Master of Technology (M.Tech.) in Computer Science	15
3.	Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	12
4.	Master of Statistics (M.Stat.)	29
5.	Master of Science (M.S.) in Quantitative Economics	19
6.	Bachelor of Statistics (Honours) (B.Stat. (Hons.))	25
7.	(a) Bachelor of Mathematics (Honours) (B.Math. (Hons.))	5
	(b) Bachelor of Mathematics (B. Math.)	1
8.	Associateship in Documentation and Information Science	6
9.	Professional Examinations in Statistics :	
	(a) Junior Diploma in Statistics	5
	(b) Senior Diploma in Statistics	3
	Total	132

3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The major thrust of the Institute is on research in various disciplines comprising Theoretical and Applied Statistics, Mathematics, Computer Sciences, Biological Sciences, Economics and other Social Sciences, Physical and Earth Sciences, Statistical Quality Control and Operations Research and Library, Documentation and Information Sciences. Scientists of the Institute carry out independent research in their own basic discipline and also undertake interdisciplinary research in collaboration with other units within the Institute and also with outside organisations. The Institute also takes up various internally and externally funded projects in diverse fields on challenging live problems of national and international importance. As a part of research activities, scientists of the Institute are involved in consultancy work as well. For academic and administrative convenience, a number of Divisions (each division having one or more units) have been formed which are listed below :

1) Theoretical Statistics and Mathematics

2) Applied Statistics

3) Computer and Communication Sciences

4) Physics and Earth Sciences

5) Biological Sciences

6) Social Sciences

7) Statistical Quality Control and Operations Research

8) Library, Documentation and Information Sciences

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

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

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

Theoretical Statistics and Mathematics Division

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

Research and Other Scientific Activities

As yet another application of techniques recently developed by us, we give a complete description of 1-complemented subspaces of finite codimension in the space of all complex-valued continuous functions on a compact Hausdorff space K with the usual supremum norm.

P. Bandyopadhyay and S. Dutta

When a Banach space X has an infinite dimensional quotient which is isomorphic to a dual space, it is easy to construct an equivalent norm on X for which the set NA(X) of norm-attaining functionals is spaceable, i.e., contains an infinite-dimensional norm closed subspace. We show that the converse holds for Banach spaces whose dual unit ball is w*-sequentially compact, and that similar results are available in spaces which share some features of Asplund spaces. On the other hand, we also show that NA(X) is not a linear subspace when a non-reflexive space X enjoys some form of the Radon-Nikodym Property (RNP).

P. Bandyopadhyay and Gilles Godefroy (University of Paris)

Simple Voting Games:

We have obtained a new characterization of Banzhaf-Coleman-Dubey-Shapley Sensitivity index and studied some of its properties. Using Fourier Analysis, we have been able to obtain tight bounds for the index for a general class of games. Properties of Coleman indices of voting power and new characterization of Banzhaf index of power have also been obtained by us.

R. Barua, S. R. Ckakravarty (ERU), S. Roy (ERU) and P. Sarkar (ASU)

Cryptography:

We have obtained two provably secure authenticated group key agreement protocols. The first one uses Weil/Tate pairings while the other one is a constant round protocol. Both protocols are dynamic. We have also obtained a constant round password-based group key agreement protocol resistant to dictionary attacks.

R. Barua and R. Datta

Two colour urn models:

A class of limit theorems on Friedman/Polya two colour urn models using tails have been established. Process convergence leading to diffusion approximation has been shown. These models have statistical applications in various sequential trials, such as, clinical trials etc. Proofs use martingale tail based technique. Among many things important results on the case when the eigenvalue of the rate matrix is bigger than half are proved.

G. K. Basak and A. Dasgupta

Generalized Polya urn:

We consider an approach based on martingale tails to certain functional central limit theorems for a class of generalized Friedman urn models which have been considered in the literature for application in clinical trials. The functional central limit theorems involve the difference of a martingale sequence Z_n and its almost sure limit Z. Our approach gives a generalization of known results with new proofs as well as some new results.

G. K. Basak and A. Dasgupta

Multicolour urn:

For multicolour urn, a result in the spirit of mixed normality is achieved. It has been shown that difference of linear combinations (in multidimension, with respect to eigenvectors) converges to a Gaussian process after scaling by different factors (for different components). Further work in multicolour urn models is in progress.

G. K. Basak and A. Dasgupta

Clinical trials:

For clinical trials, strong law has been proved for odds ratio. Odds ratio is a natural measure used by practitioners for allocating patients to different treatments. Process convergence for an increasing function of odds ratio has been established through diffusion approximation technique. Further work on the central limit theorem for odds ratio is in progress.

G. K. Basak, A. Biswas (ASU) and Stas Volkov (University of Bristol)

Estimating efficient portfolio:

In estimating the risk in sample efficient portfolios we show that the in-sample estimate of the conditional variance of an efficient portfolio constructed using an estimated covariance matrix will on average be strictly smaller than its true variance. In the case of the global minimum risk portfolio, scaling the in-sample estimate upward by a *standard* degrees-of-freedom related factor can be inadequate. The correction is likely to be twice as large as the standard correction when returns are i.i.d. multivariate Normal. Using the Bayes covariance matrix estimator does not help overcome this problem. We develop a Jackknife-type estimator of the minimum risk portfolio's conditional variance that is valid when returns are i.i.d.; and a variation that may be better when returns exhibit volatility persistence. We empirically demonstrate various results (obtained above) using real data from S&P500.

G. K. Basak, Ravi Jagannathan (NorthWesternUniversity)
and Tongsh Ma (University of Utah)

An extension of Mahalanobis' Fractile Graphical Analysis applicable to data involving multiple covariates has been developed. This extension involves some multivariate versions of fractiles and new inferential tools for statistical comparison of nonparametric function estimates. This has been applied to econometric data obtained from Reserve Bank of India related to banks and companies in the country leading to some interesting results.

P. Chaudhuri

A statistical method has been developed for identifying horizontally acquired genetic materials in bacterial genomes. The method was applied to various genomes of vibrio bacteria. The horizontally acquired segments in the vibrio genomes discovered by the statistical method were found to have important association with the patheogenic activities of the vibrios. The method developed leads to valuable insights into the genomic evolution of different vibrios. This is joint work with scientists from Indian Institute of Chemical Biology, Jadavpur.

P. Chaudhuri

Some progress has been made towards the development of probabilistic models for DNA sequences which can be used to build statistical gene predictors. Such gene identification methods based on the principles of statistical learning are expected to lead to improved annotation techniques for prokaryotic and eukaryotic genomes.

P. Chaudhuri, A. Dasgupta and R. L. Karandikar

Let G be the Grassmannian of k-planes in n-dimensional Euclidean space. We define a sequence of even-dimensional forms on G (which are coefficients of the Chern character form) and prove that an arbitrary even-dimensional form on a manifold M can be obtained from one of these forms on G through an immersion of M into G.

M. Datta

It has been shown that over a noetherian normal domain R, a faithfully flat subalgebra of a finitely generated algebra whose generic and codimension one fibres are A^1 is necessarily the symmetric algebra of an invertible ideal of R. A structure theorem for a faithfully flat algebra over a factorial domain whose generic and codimension one fibres are A^1 has been obtained. The result gives a minimal sufficient condition for the algebra to be finitely generated and hence A^1. A striking feature of

the results is the sufficiency of conditions on merely the generic and codimension one fibres for determination of the structure of algebras of transcendence degree one.

A. K. Dutta and N. Onoda (University of Fukui)

Efforts have been made to extend the Baum – Connes Conjecture for discrete quantum groups formulated earlier by us to general locally compact quantum groups. Some new ideas in this direction are being explored, with partial success.

D. Goswami and A.O. Kuku (I.C.T.P., Italy)

A set of complete local invariants for a wide class of mixed bi-partite quantum states have been defined and studied.

D. Goswami, S. Albeverio (University of Bonn, Germany)
and S.M. Fei (University of Bonn, Germany)

Some new invariants for completely positive normal maps on the hyperfinite type II_1 factor are defined, and how these invariants help us to classify extreme points of the set of such completely positive normal maps has been shown.

D. Goswami and L. Sahu

Research on dilation of quantum dynamical semigroups with unbounded generators has been continued. Evans- Hudson dilution for a class of such semigroups has been constructed.

D. Goswami, K.B. Sinha and L. Sahu

An approach for examining dynamic relationship between multiple brain regions has been proposed in Ho, Ombao and Shumway (*Statistica Sinica*, 2005). Their approach assumed that the quantity representing the influence of one neuronal system over another, or *effective connectivity*, is time-invariant. However, more and more empirical evidences suggest that the connectivity between brain areas may be dynamic which calls for temporal modeling of effective connectivity. A Bayesian approach is proposed to solve this problem. The proposed method was applied to a functional magnetic resonance imaging dataset and results support the theory of attentional control network and demonstrate that this network is dynamic in nature.

S. Purkayastha, S. Bhattacharya (ASU) and
Moon-Ho Ringo Ho (McGill University)

The functional significance of the alpha rhythm in humans is not known definitively. Alpha band activity has been used as an indirect measure of brain activation because increased activity in the frequency range is considered to be corresponding to decreased functional activity in underlying cortex. The identification of generator regions using scalp EEG alone, however, is challenged by the fundamental difficulties in localizing sources in a conductive volume from only surface information. In order to address this problem of localization, a current trend is to look at data collected simultaneously from EEG and some modality of medical imaging. The present work reports findings of one such investigation on a simultaneous EEG-fMRI experiment. Our work employs a recently introduced model selection algorithm, applicable in the context of linear models. This algorithm is known as *Least Angle Regression*. It has to be stated here that all our analyses are repeated for bands of EEG activity other than alpha -- like beta, theta, and delta.

S. Purkayastha, Robin I. Goldman (Columbia University)
and Keith J. Worsley (McGill University)

A Markov Chain Monte Carlo method has been developed to generate a random self avoiding path from a corner to the opposite corner in a rectangular grid. This can be used to estimate the distribution of any function of such a path. These paths have applications in Computer Science and Physics.

A. R. Rao and Arunava Sen (Arizona State University)

Energy of Graphs, Hypergraceful Complete Graphs, Ramsey Type Theorem for almost all Directed Graphs: The energy E(G) of a graph G is the sum of the absolute values of the eigen-values of the adjacency matrix of the graph G. Research is being pursued on the determination of the set of

energies of all the graphs. Further determination of the maximum energy of all graphs on p vertices with a specified property P, like planarity is being tried. Research is going on to show that almost all directed graphs D have the property that either D or its complement digraph has a directed cycle of length n, where n is a fixed integer greater than 3, an almost Ramsey type theorem for Digraphs. Characterization of k-hypergraceful complete graphs is being tried for $k > 2$. Partial results have been obtained on all these problems.

S. B. Rao

A study on the bounds of the possible sizes of the minimal critical sets in Orthogonal Array OA $(n^2, k+2, n, 2)$ constructed from k mutually orthogonal cyclic latin squares of order n has been undertaken. In particular for $n = 7$ and 9 critical sets have been identified and for $n \geq 11$, odd, an upper bound has been obtained.

R. SahaRay, Avishek Adhikari and Jennifer Seberry (Univ. of Wollongong)

Characterization of optimal designs for comparison of test treatments to two controls of unequal importance using weighted A – optimality and weighted MV – optimality criteria have been undertaken.

R. SahaRay and N. Dasgupta (Washington State University)

Two period Repeated Measurement designs under the model allowing two types of carry over effects (simple carry over and mixed carry over) have been studied. Some good designs with minimum number of subjects needed to estimate unbiasedly all pairwise contrasts in mixed carry over effects have been identified and shown to be A – optimal within a proper subclass of competing designs.

R. SahaRay and Kirti Shah (University of Waterloo)

A Graph $G = (V, E)$, with $|V(G)| = p$ and $|E(G)| = q$ is said to be *k-hypergraceful* if there exists a decomposition of G into *edge-induced subgraphs* $G_1, G_2, \ldots, G_k$, having sizes (i.e., the number of edges) $m_1, m_2, \ldots, m_k$ respectively, where $\Sigma_{i=1}^{k} m_i = q$ and an injection $f : V \to \{0, 1, 2, \ldots, q\}$ such that when each edge $uv \in E(G)$ is assigned the absolute difference $|f(u) - f(v)|$ then the set of integers received by the edges of G_i is precisely $\{1,2,\ldots,m_i\}$ for each $i \in \{1,2,\ldots,k\}$; We have characterized 2-hypergraceful complete graphs K_p, $p \leq 6$. Also, we have proved that there are infinitely many complete graphs which are not k-hypergraceful for any $p \geq 4$, $k \geq 3$. Partial results have also been obtained in this case.

T. Singh, S. B. Rao, B.D. Acharya (Department of Science and Technology) and M. Acharya (Delhi College of Engineering)

Given a graph $G = (V, E)$, a subset $D \subseteq V$ is called a dominating set (or, simply a *domset*) of G if every vertex in G is either in D or is adjacent to a vertex in D. Acharya, Rao, Sumathi and Swaminathan, had introduced the notion of *"Robust domination energy of a graph"*, denoted by $\varepsilon_r(G)$ through the eigenvalues of an appropriate adjacency matrix. We have proved that for any connected graph G of order n, $\varepsilon_r(G) \geq n-1$, and this result is best possible for all $n \geq 2$. Further, a good characterization of all connected graphs of order n with $\varepsilon_r(G) = n-1$ is given.

T. Singh and S.B. Rao

A study of statistical properties of apportionment index, abbreviated as AI, in the context of forestry research has been initiated. This index seeks to measure the agreement between a target matrix and a supply distribution of diameter length-width specifications of logs.

B. K. Sinha, Tapio Nummi (University of Tampere, Finland) and Laura Koskela (University of Tampere, Finland)

For exponential life distribution, a study of the characterization of the UMVUE of the reliability function at a fixed time point based on "broken" samples has been initiated. Here broken sample refers to a collection of some selected order statistics in a random sample from the population.

B.K.Sinha, Samindranath Sengupta (Calcutta University) and Sujay Mukhuti (Calcutta University)

In the context of market research strategies, there is a popular concept of Pareto Optimal Sets dealing with different equivalent options to be offered to the customers. A characterization of such sets is of intrinsic interest and we have initiated some studies along this direction.

B.K. Sinha, R. SahaRay and N.K. Mandal (Calcutta University)

Studies along the direction of characterization and construction of optimal regression designs in the context of heteroscedastic errors have been initiated.

B. K. Sinha, N.K. Mandal (Calcutta University)
and P. Das, (Kalyani University)

Skew normal distributions, introduced by Azzalini (1985), are being increasingly appreciated in the application areas involving curve fitting. A study of the basic properties of these distributions has been initiated.

B. K. Sinha, Tapio Nummi (University of Tampere, Finland), Anne Puustelli (University of Tampere, Finland) and Jarkko Isotalo, (University of Tampere, Finland)

In the context of statistical ecology, some probability inequalities have been established regarding the discovery of "new" species with arbitrary species distribution.

B. K. Sinha and A. Goswami

In a non-parametric set-up, some studies have been undertaken for estimation and construction of bounds for prototype testng.

B. K. Sinha, Avinash Dharmadhikari (Pune University)
and Sanjay Sabnis (IIT, Mumbai)

Dyadic relational models, as discussed in Wasserman and Faust (Social Network analysis, 1994) have been applied to actual networks obtained from surveys conducted in some villages in Jharkhand/West Bengal. In this context, the prospect of cross-classification models is also being investigated.

B. K. Sinha, A. R. Rao, S. Bandyopadhyay (Sociological Research Unit)
Montip Tiensuwan (Mahidol University, Thailand) and Pharita Em-ot
(Mahidol University, Thailand)

The problem of detection of counterfeit coin(s) most efficiently has perplexed all those who have tried to understand its intricacies! This is an interesting area of research mainly because of its combinatorial and matrix-related aspects. We have initiated a study on the matrix version and developed improved algorithms.

B.K. Sinha, S.B. Rao and P.S.S.N.V.P. Rao (ASU)

Stat-Math Unit, Delhi

Research activities

Continued research on the properties of matrices associated with graphs, particularly distance matrix and Laplacian matrix. New formulas for the determinant and the inverse of the distance matrix of a tree were obtained.

R.B. Bapat

Continued research on analysis of matrices and harmonic analysis.

R. Bhatia

Continued to work on problems related to martingale problems - in particular, to the characterization of Markov processes via martingale problems and on filtering theory where the observation noise is a process other than a Standard Brownian motion.

A. G. Bhatt

Optimal fractional factorial plans in presence of main effects and selected two factor interactions were derived from orthogonal arrays of strength two. Furthermore, non-orthogonal blocking methods have been obtained such that when applied to orthogonal arrays, the designs retain universal optimality property. In the area of designs for diallel cross experiments, efficient designs have been obtained for estimation of heritability.

A. Das

Continued with the study of inequalities for nonmonotonic functions of associated random variables. Also studied parametric models for accelerated testing under competing risks and continued with the study of independence of time to failure and cause of failure.

I. Dewan

Optimal designs for diallel cross experiments when specific combining ability effects are included in the model were obtained. A detailed analysis of small orthogonal arrays of strength two, permitting the estimation of specified 2-factor interactions was carried out. A method of allocating factor representations to the columns of an orthogonal array such that the main effects and specified 2-factor interactions are optimally estimable was developed.

A. Dey

Continued work on Martingale problems, characterization of Markov processes and filtering theory. Worked on software implementation Markov Chain Monte Carlo methods (MCMC).

R.L. Karandikar

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

S. C. Kochar

Continuing earlier work on noncommutative geometry and its interplay with quantum groups, the odd dimensional quantum spheres that arise as homogeneous spaces of the quantum groups $SU_q(n)$ were investigated and a characterization theorem was obtained for all equivariant spectral triples on its L_2 space, which generalizes our earlier result on $SU_q(2)$.

A. Pal

Continued efforts to solve some well-known open problems of quantum information theory touching on (a) estimation of density operators for systems with finite number of levels; (b) entanglement; (c) quantum coding theorems.

K.R. Parthasarathy

Continued work on statistical inference problems for stochastic partial differential equations and for processes driven by fractional Brownian motion. Worked on characterizing with bivariate lack of memory property under binary associative operation. Partial sums of zero mean negatively associated random variables form an N-demimartingale. Maximal inequalities for such processes were derived.

B.L.S.P. Rao

Worked on random graphs and in percolation theory. Work is being done on obtaining a distance measure between genomes.

R. Roy

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

A. Sarkar

Stat-Math Unit, Bangalore

Research Activities

Studied two types of interacting particle systems: (a) Ergodic properties of Branching Coalescing Systems and (b) Infinite Volume limit of Sandpile Model. Also studied a coverage model that is useful in contig analysis of DNA sequences.

S. Athreya

Determined the product system of regular quantum Markov cocycles as continuation of work started last year.

B.V.R. Bhat

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

Solutions to the research problems of the above lead to several interesting and important problems in probability theory, the solutions of which are also of current interest. In particular, the weak convergence, both of first order and second order, of nonlinear functionals of sums of fractionally integrated processes to local times of fractional Brownian motion and stable motions.

The probability problem as mentioned above also leads to some general results on the convergence of partial sum process to mixtures of infinitely divisible processes.

These general results in turn lead to interesting and important limit theorems in some network traffic models.

A study of the evolution of the decimal place value system in India, viewed as the evolution of a complex system. Important results have also been obtained with regard to the writing of the archaic Sumerian clay tablets, by relating it to certain aspects of the writing of the Indus Valley Civilization. These studies are related to, and based on, the earlier published studies on the script of the Indus Valley Civilization.

P. Jeganathan

Groups none of whose representation has any rate of random mixing are being considered. The notion of rate of random mixing was introduced by Shalom to bound the critical exponential rate of mixing from below. By applying Kawada-Ito Theorem it was shown that no finite-dimensional representation has any rate of random mixing. In particular, it has been proved that no representation of Moore groups has any rate of random mixing. It was also shown that no representation of affine groups has any rate of random mixing.

C.R.E. Raja

There have been some new developments in the research on `last entrance times'. Earlier research had focussed on their applications to Martingale theory and stochastic calculus. It turns out that they have interesting applications in Markov process theory also. The main result is that if (X_t) is a Markov process then the process $(X_t - X_{\sigma_t}, X_{\sigma_t})$ is also a Markov process.

Some of the recent work has been on stochastic differential equations in infinite dimensions. This has led to a new formulation of the Martingale representation theorem. A paper titled `A New approach to the Martingale representation theorem', written jointly with P.Fitzsimmons, describing this research, has been submitted for publication.

Work is going on on infinite dimensional SDE's. This provides some new insights into the relationship between SDE's and partial differential equations, viz. the Kolmogorov forward equation for the transition probabilities of a Markov process. By rewriting the SDEs as a stochastic partial differential

equation, the forward equation arises by the simple device of taking expected values in the stochastic PDE.

B. Rajeev

Work continued on several aspects of geometry of Banach spaces. The notions of transitivity of proximinality were studied for factor reflexive subspaces. It was shown that the space of compact operators on a separable Hilbert space has this property. Any proximinal subspace of finite codimension in the c_0 direct sum of uniformly convex spaces was shown to be strongly proximinal.

T.S.S.R.K. Rao

Work continued on determination of maximal subgroups of $F_4(q)$ using the structure of the associated quadratic Jordan algebra.

Determination of the module structure of the binary code associated with the group $SP(4,q)$ as module for the stabilizer of the ovoids in the corresponding generalized quadrangle.

Determination of nonabelian representations of finite polar spaces. Characterization of polar spaces of finite rank and odd prime order as the only finite polar spaces of prime order which admit nonabelian representation.

N.S.N. Sastry

Wreath products of groups were studied in relation to bounded cohomology and bounded generation property. A criterion for triviality of the singular part of their second bounded cohomology was established and it was also determined when wreath products of groups have bounded generation.

A general polynomial identity in $k \geq 2$ variables was obtained which was used to give a closed-form expression for the entries of the powers of a $k \times k$ matrix. This was used to derive various combinatorial identities. Following this, the above results were applied in another publication to investigate a procedure of Khovanskii's for extracting roots of an arbitrary polynomial. It was also shown how to choose the optimal value of a free parameter to get maximum speed of convergence.

For an arbitrary polynomial g of degree ≥ 3 over Q, finiteness of the set of rational solutions with bounded denominators (with necessary exceptions) was established for a class of equations of the form $f(x) = g(y)$ which includes the polynomials $f(x) = \sum_{k=0}^{n} x^k / k!$ and the Bernoulli polynomials $B_n(x)$, for any $n \geq 3$.

For any finite commutative ring A with unity, the polynomial $S_A(x) = \Pi_{a \in A} (x - a)$ had been studied by some authors with reference to Kronecker's jugendtraum. Some properties of this polynomial were investigated and a question posed by them regarding its additivity was answered.

B. Sury

Work done under externally funded projects :

Swarnajayanthi Project:

Work was done to prove an extension of Shale's theorem and to show that `Shale map' respects compositions This settles an old conjecture of K. R. Parthasarathy. This is used to associate a product system to a sum system. This gives purely Functional Analytic approach to the probabilistic construction of type III product systems by B. Tsirelson. This leads to new insights to understand product systems coming from sum systems and their invariants. For instance, it is shown that divisible sum systems can never give rise to type II product systems.

Consider a tensor product $H = H_1 \otimes H_1 \otimes \ldots \otimes H_k$ of finite dimensional Hilbert spaces with dimension of $H_i = d_i, 1 \leq i \leq k$. Then it is a result of K. R. Parthasarathy that the maximum dimension possible for a subspace of H with no non-zero product vector is known to be $d_1 d_2 \ldots d_k - (d_1 + d_2 + \ldots + d_k) + k - 1$. An explicit example of a subspace of this kind is obtained. The set of product vectors in its orthogonal

complement has been determined and it is shown it has the minimum dimension possible for an unextendible product basis of not necessarily orthogonal product vectors. A preprint on this is ready.

B.V.R. Bhat

Studies in geometry of Banach spaces

A well known result of Hopenwasser and Plastiras on into isometries on the space of compact operators on a Hilbert space was extended to a certain general class of Banach spaces.

Nice surjections on spaces of operators were studied and an anlogue of a result of Labuschagne and Marcioni was proved for nice operators between spaces of compact and bounded linear operators.

T.S.S.R.K. Rao

Applied Statistics Division

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

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

Applied Statistics Unit

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

Research and Other Scientific Activities

Sample Surveys

Research was done in the area of Adaptive and Network Sampling especially with constrained sample-size.

A. Chaudhuri and M. Bose

Appropriate unbiased estimators in multi-stage sampling, when the initially selected samples are to be curtailed at the survey-stages, were derived. Application of bootstrap in two-stage sampling with unequal probabilities was explored. Randomized Response and related techniques of indirect questioning.

A. Chaudhuri

Cryptology

Symmetric cryptography: Analysis of Klimov-Shamir T-functions and their weakness as stand-alone pseudo random generators were shown; construction of Boolean functions with some kind of provable resistance to algebraic attacks were obtained.

B. Roy, S. Maitra and P. Sarkar

Asymmetric cryptography: New protocols for hybrid encryption; implementation of Tate pairing; provably secure authenticated key agreement protocol.

P. Sarkar

Hash functions: constructions and theoretical properties of UOWHFs; construction of hash functions with good rate.

B. Roy and P. Sarkar

Visual cryptography: New constructions for visual threshold scheme using combinatorial designs.

B. Roy

Steganography & Digital water marking: Primarily cryptanalysis of some existing schemes were carried out.

S. Maitra

Inference

Some new robustness techniques based on minimum distance ideas have been developed. In the context of multinomial goodness-of-fit tests, some results have been developed which lead to generally more powerful tests under the composite 'not equal to' alternative. Some new correlation inequalities have been developed under the Gaussian set up, and some existing results have been extended in this context. In the area of longitudinal growth curve models, goodness-of-fit tests have been developed for the exponential and Gompertz models. Currently attempts are on to extend them to other growth curve models.

A. Basu

Some modification of Orban-Wolfe partial sequential procedure has been suggested. The properties of the proposed procedure has been studied in detail.

A. Biswas

Multivariate Analysis

Given paired data from two populations, the problem of classification between the populations was considered. A nonparametric classification rule based on a set of incomplete and complete pairs of data was devised and its large sample properties explored. The classifier has applications in Medical Statistics and Biometry.

D. Sengupta and S. Bandyopadhyay

Admissibility and Bahadur optimality of the LRT for Generalized Variance have been established. The theory and applications of Generalized Canonical Variables have been reviewed. Dependency properties of certain multivariate distributions have been studied in terms of their parameters.

A. Sen Gupta

Signal Processing

The problem of predicting the extent of wear of cutting tools in various machining operations is important for preventing tool breakage and ensuring optimal usage of tools with uninterrupted operation. A novel technique of predicting tool wear from electrical signals of spindle motor in a face-milling operation was developed. Electrical sensors are less invasive in comparison to other sensors (e.g., of cutting force, acoustic emission, vibration), and relatively cheaper. Further, robustness of the method from environmental disturbance makes it an attractive option.

D. Sengupta and P. Bhattacharya

Directional Data Analysis

Probability distributions on r-manifolds ($r \geq 3$) have been constructed through maxent and conditional specification characterizations. Constructions of and optimal inference for axial distributions have been

obtained. Constructions and inference for asymmetric circular distributions and processes have been explored. Dependency analysis for distributions on the torus and cylinder for some parametric families have been pursued. Directional regression analysis for some real-life data has been conducted. The importance and usefulness of circular statistics in Bioinformatics have been investigated.

A. Sen Gupta

Reliability Inference and Survival Analysis

New models and tests for Accelerated Life Testing have been proposed. Parametric and non-parametric inference in models with concomitants of order statistics have been studied. Online and retrospective change-point optimal tests for several parametric linear and circular families of distributions have been derived.

A. SenGupta

Bayesian Analysis

A unified and conveniently implementable approach to Bayesian inference for probability models on the torus with implicitly defined normalizing constants has been obtained. Full Bayesian changepoint analysis with some circular parametric models has been proposed.

A. SenGupta

Adaptive Design

A general adaptive design was formulated to deal with continuous responses in the presence of covariates in a phase III clinical trial set up. Properties of the design were studied in detail. Some research on adaptive designs for survival data and adaptive designs under crossover set up was also carried out. A general optimal adaptive design was studied which maximized utility.

A. Biswas

Categorical Data Analysis

A general model was obtained for longitudinal categorical data set up and some related inference was carried out. Odds ratio in 2×2 contingency table was theoretically studied under some situations where the usual asumptions do not hold.

A. Biswas

Other Areas

The genetic effect in a twin study was statistically formulated and studied.

A. Biswas

Projects:

A. Internally Funded Projects

Implementation of provably secure public key protocols

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

Robust estimation and goodness of fit tests for circular models

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

Effect of traffic noise on hearing of school children in Kolkata

Most of the time was devoted to organizing and conducting the project work related to effect of Traffic Noise on the Hearing Ability of the School children of Kolkata. The data collection is almost over, the analysis and report-writing are to be done.

Externally Funded Projects

Reliability Estimation of a Solid Rocket Motor with Limited Data

The aim of this project is to build an empirical model for predicting the values of various performance parameters of a solid propellant rocket motor, and to evaluate the probability that these parameters are within their ballistically predicted limits. A regression model has been developed for this purpose and the resulting predictions are being tallied with observed data as well as experts' experience.

Evaluation of reliability of a unit of flight control software

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

Software development for tiger pugmark analysis

The aim of this UNDP/WB Govt. sponsored project is to determine whether pugmarks can be used to identify tigers in the Sundarbans, and to develop a suitable clustering strategy to arrive at an estimate of population total at the time of the 2004 census. Field experiments were conducted to study the variation of various features across replications, and some discriminating features were identified. The method is being fine tuned to utilise an optimal number of features and to incorporate spatial information.

Visual cryptographic schemes

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

Sample surveys of elephant population in elephant reserves of West Bengal

This project started in March 2005. The aim is to provide statistical advice on conducting elephant survey in some areas of West Bengal and on subsequent data analysis.

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

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

Steganographic Schemes for Satellite Images for ISRO

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

Cryptanalysis and design of steganographic schemes

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

Development of an Indigenous Block Cipher Scheme for ISRO

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

Investigation of means to assess errors in surveys by judicious techniques

The project is still continuing. The papers produced were mentioned elsewhere.

Development of algorithm for robust speaker identification by statistical methodology

The project, funded by the Department of Information Technology, Government of India, commenced in ASU on the 29th of March, 2004. Investigations are going on to find new features/classification schemes that may lead to improved recognition accuracy. As a part of this project, a workshop on the state of the art in the area of speaker recognition, was organized during the 28th and 29th of January 2005, in which tutorials/talks were presented by seven eminent researchers in this field from all over India.

Statistical classifiers for encryption algorithms

The project aims to study a large number of crypto algorithms and tries to distinguish between them when the source is unknown based on the known cipher text attack.

Computer and Communication Sciences Division

Advanced Computing and Micro Electronics Unit

During the period 2004-2005, the faculty of the unit were engaged in research in various major areas of computer science. The research comprises theoretical and applied research in the areas of high performance computing, pervasive and mobile computing, VLSI design tools and electronic design automation, logic synthesis and testing, error correction and fault-tolerance, physical design of microchips, embedded systems, system-on-a-chip, low-power architectures and test methodology, computational geometry, algorithms and data structures, computational biology, hardware for image processing; nano-technology and giga-scale integration techniques.

Mobile Computing

Home-networking and personal networks are becoming popular in modern age of pervasive computing. Bluetooth technology offers a solution for connecting several bluetooth devices roaming around within a short range. To communicate beyond the range, as well as to increase the number of nodes, several bluetooth *piconets* may be connected through some *bridges* to form a *scatternet*. Given a set of *n* nodes, an energy-efficient distributed algorithm has been developed to form a scatternet. Simulation studies show that it performs better than the algorithms reported so far in terms of improved topology as well as power saving.

N. Das and S. Bhattacharjee

In wireless communication, radio spectrum is a very scarce resource that is to be managed efficiently. We propose some dynamic channel assignment strategies that start with a known demand but from time to time can accommodate new perturbations in the demand with some rearrangement. Simulation studies on the well-known *Philadelphia benchmark* problems show that the proposed algorithms perform better than the earlier ones both in terms of computation time and blocking.

B. P. Sinha, N. Das and S. C. Ghosh

Another form of wireless network without any infrastructure is ad hoc network. One of the important problems in ad hoc networks is to find an efficient routing algorithm. Routing based on connected dominating set is a promising approach. A simple and efficient two-phase distributed algorithm has been developed which outperforms earlier methods in terms of cardinality of the set and number of message exchanges.

J. Dattagupta

Geometric Algorithms

The research in this area is mainly focused on different geometric optimization problems, with applications to facility location, mobile computing, GIS, etc. Encouraging results are obtained on identifying the smallest k point enclosing rectangle of any arbitrary orientation.

P. P. Goswami, S. Das and S. C. Nandy

In GIS, the constrained shortest path in 2D and 3D (polyhedral terrain) with obstacles is thoroughly investigated. The analysis of a terrain with an objective to identify the shortest path with specific visibility characteristic (e.g. avoiding guards, radar, etc.) is in progress. The multiple watch-tower installation problem for guarding a terrain is also to be considered.

S. Roy, S. Das and S. C. Nandy

In the context of mobile computing, efficient algorithms are designed and implemented for (i) the optimum range assignment problems on already installed radio stations, and also (ii) identifying the locations for installing the radio stations such that the total power consumption becomes minimum.

G. Das, S. C. Ghosh, S. Das and S. C. Nandy

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

Parallel Algorithms related to Fragment Assembly in DNA Sequencing

The database of complete genome sequences for various living organisms is continually growing. The key steps for DNA sequencing are shattering multiple copies (clones) of the whole genome into several fragments, then performing fragment assembly to discover long stretches of genome. The overlapping fragments of the genome should ideally form an interval graph. However, experimental inaccuracies may creep in with missing fragments. Non-contiguous fragments may also attach to form a chimera.

Implementation of a well-known sequential algorithm for recognition of interval graphs based on a special data structure called PQ trees has been completed. A new recognition method has been devised based on the fact that dominating sets of interval graphs can be determined in linear time. A sequential algorithm to determine the interval number as well as the interval representation of a few special classes of graphs has been designed and implemented.

S. Sur-Kolay and S. Mukhopadhyaya

VLSI Physical Design Automation

With the increase in system-on-chip design platforms along with the technological advances in FPGAs (Field programmable gate arrays) in terms of density, speed and performance, the need for very fast FPGA design tools has become very pressing. Two methods for accelerating the placement phase of FPGAs upto 50% compared to the best existing tool, and even additional improvement in quality of solution have been devised. The main thrust is on obtaining a very good quality initial placement, instead of a random one, and then performing nominal ultra low temperature simulated annealing thereby leading to reduction in time. While the first method is a deterministic, polynomial time, greedy bottom-up approach for placing the output cones, the second one employs top-down balanced bi-partitioning to obtain a linear order of the blocks to be placed which are then mapped by a recursive space-filling curve function.

Another problem addressed deals with multi-layer routing of giga-scale integrated circuits. A graph-search based algorithm for topological routing has been completed and validated on reasonably large problem instances.

S. Sur-Kolay and P. Banerjee

Test methodology for Power Supply Droop Noise Induced timing faults

While performance and density gains have soared up due to smaller transistor feature size, so has semiconductor power density. Microprocessors of today have power density of about 60watts/cm^2 and this figure may be extrapolated to about 200Watts/Cm^2 by 2010. This emphasizes the criticality of maintaining steady power supply, with diminishing voltage levels as well, to the device layers through multiple layers of metal on one hand. On the other hand, delay sensitivity to power supply variation is also on the rise, thereby raising the importance of reliable distribution of power manifold. This issue has three facets: analysis of the problem, synthesis of power distribution network and targeted test development to expose performance impact when practical constraints limit us from designing a fully comprehensive power supply design. The first issue has been addressed and a methodology for modeling gate delay faults from power supply droop noise was developed. Based on this model, a methodology to generate test patterns for detection for droop induced transition faults in a given combinational circuit has been designed and implemented.

S. Sur-Kolay

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

Designing of zero-aliasing space compactor for response compaction in a sequential circuit has been investigated. For scan-based sequential cores, a new technique has been developed to synthesize a zero-aliasing compactor based on a novel concept of distinguishing lines and characteristic function of the response matrix. The proposed compactor is applicable to any arbitrary sequential circuit, and provides single-output (maximum) compaction with zero (minimum) aliasing. This solves a long-standing open problem in compactor design: till date, it 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.

It is also shown that test response compaction can be utilized for designing the BIST of circuits that are used for encryption. Without compaction, scan test data can be analyzed to discover the circuit structure and to break the encryption.

B. B. Bhattacharya

Multi-Mesh Architectures

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

B. P. Sinha and S. Bandyopadhyay

On-Chip Implementation for Content-based Image retrieval

We address the content based image retrieval (CBIR) problem using novel ideas of combinatorial characterization of an image, computational geometry, and data mining. Parameters like Euler Number, Euler Vector, geometric distribution of control points, etc. have been considered for characterization of an image. Applications to image database searching and fingerprint analysis have been studied. On-chip VLSI architectures of these algorithms have been designed. Future generations of personal and mobile computers are likely to provide on-chip implementation of CBIR to accelerate image searching and retrieval. CBIR has versatile applications to internet surfing, forensic, medical and geographical image processing. New techniques for torn paper matching have been developed, with applications to forensic science. Polygonal approximation of various shapes, and its applications to CBIR has been investigated. This work is currently being pursued under a collaborative project with

MIU, ISI and Intel Corporation, USA. Eight patents have been filed at the US Patents and Trademark office.

B. B. Bhattacharya and A. Bishnu

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 scheme have been proposed which work for the unidirectional and bi-directional ring networks. These algorithms outperform the existing algorithms in terms of number of messages and time. A new scheme for checkpointing and recovery using mobile agents has been proposed. Some existing checkpointing and rollback recovery schemes have been analyzed under a stochastic model. The expressions for average cost of checkpointing, rollback recovery, message logging and piggybacking with application messages in synchronous as well as asynchronous checkpointing have been derived. Selective message logging protocol, process logs messages selectively instead of all messages. The upper bound and lower bound of selectively message logging have been evaluated.

K. Mukhopadhyaya and P. S. Mondal

Sensor Networks

In a sensor network, finding the location of an object, other than a sensor, is an important problem. In the absence of good techniques, we have proposed a method to solve this problem, assuming that the locations of the sensors are known. A sensor can only detect the number of objects in its neighborhood, thereby injecting low volume traffic in the network. The computations are carried out entirely at the base station.

K. Mukhopadhyaya and P. S. Mondal

Computer Vision and Pattern Recognition Unit

Document Analysis

There are printed artistic documents where text lines of a single page may not be parallel to each other. These text lines may have different orientations or the text lines may be curved in shape. As a result, it is very difficult to detect the skew of such documents and hence character segmentation task of such documents is difficult. We developed a system for segmentation of characters from artistic documents of Devnagari and Bangla scripts without any skew correction. Also, to recognize artistic documents of English characters, we proposed a method of recognizing multi-oriented and multi-sized English isolated characters. The recognition technique is mainly based on the features obtained from the contour distances calculated from the centroid of the characters. A system for recognition of Bangla and Devnagari multi-oriented characters has been developed. A modified system for word-wise script identification of most of the Indian bi-lingual documents has been developed. A system for English and Japanese script identification has also been developed. A corpus of printed mathematical expressions has been constructed to facilitate the OCR research on equation/formulae. A multiple classifier system has been designed to recognize printed mathematical symbols.

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

Analysis of low quality historical color document images

Digital archival and processing of historical paper documents has recently been an active research area in the field of document image analysis (DIA). This project deals with finding an efficient approach for foreground/background separation in historical documents available in gray or color domain. The proposed approach is based on a few processing steps the first of which executes a connected component labelling in gray/color domain. Non-uniformities in the background color are captured to tackle uneven illumination and other degradations. Foreground parts are not treated against any global background, rather they are processed with respect to their closest backgrounds. The method shows

enormous adaptability to tackle noise, uneven illumination and low contrasted background and foreground colours. Experiments were carried out on several documents of historical nature like images scanned from the working notebooks of several famous writers like Gustave Flaubert (1821-1880) and James Joyce (1882-1941), etc. Test results show that marked improvement is achieved by the proposed method over some existing techniques like DjVu, bicolour clustering, etc.

U. Garain

Handwritten Character Recognition

Two large databases of handwritten isolated Bangla vowel modifiers and compound character samples have been developed. Recognition accuracy of handwritten Bangla numerals has been improved by combining multiple combination rules of multiple classifiers. A scheme (shape analysis based) for recognition of handwritten basic characters has been designed. Preliminarily, we developed a few shape features providing promising recognition results on our database for Bangla basic characters. Also, significant progress has been obtained towards the development of a semi-automatic form processing system. Such a system will be very useful and robust for automatic extraction of necessary data from hand-filled-in forms. Additionally, a scheme for joining broken numerals extracted from noisy images of Indian postal documents has been developed. Another scheme for identifying the script (Devnagari/Bangla) used in the handwritten address part of an Indian postal document has also been developed. Finally, a scheme for line, word and character segmentation from handwritten text of Oriya script has been developed.

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

Natural Language Processing

An electronic English – Bengali Official Terminology dictionary of about 8000 words as well as phrases had been developed under this project. This will be useful in machine translation of official letters and documents. Substantial progress has been made on developing an electronic English – Bengali general purpose dictionary, which will be helpful in NLP activities. Small modules of phrasal Machine Translation from Bangla to English and English to Bangla have been developed. However, complete machine translation is a long way to go. Now, different multi-word constructs possible in Bangla language have been categorized. Implementing them in computer has also started. A book entitled "Corpus Linguistics and Language Technology" has been published by Dr. N. S. Dash of this unit.

B.B. Chaudhuri and N.S. Dash

Digital Data Compression and Security

This project investigates digital data compression and security issues in the context of technology development in Indian languages. Objective of this project is to design efficient algorithms for compression of Indian language documents available in electronic text and image format. The issues of copyright protection and data authentication are also being studied. During the period of April 2004 – March 2005, a technique for compression of Indian language imaged documents (textual) has been designed. Some compressed domain processing has also been studied. Development of a document image retrieval system is in progress. An encryption scheme for watermarking the (textual) images to be compressed has been designed and the loss of quality of the watermarking is being assessed.

U. Garain and S. Palit

Information Retrieval

Work on cross-lingual information retrieval from Indian language documents continues. A test collection for IR, comprising a corpus of about 50,000 Bengali documents, and a set of 30 sample queries, has been constructed. Using the corpus, a language-independent approach to stemming has been developed. Test results on standard English benchmark data are very encouraging. Term association information has been collected from the corpus, and will be used to construct an automatic thesaurus. A preliminary, n-gram-based transliteration module has been constructed. This will be useful in constructing a cross-lingual retrieval engine. Some preliminary investigations into sentence-

level information retrieval have been completed. Results are promising, and more experimentation is needed.

M. Mitra and P. Majumder

A Generalized Transform for Signal Processing

A new and generalized transform (called ISITRA) for signal decomposition and reconstruction has been developed which can be used for signal processing tasks like compression, encryption etc. It has been shown that the proposed scheme has several advantages over the existing transforms like wavelets and filter bank. The space of perfect reconstruction filters (PRF) is much larger in ISITRA than in the existing transforms. A search technique has been developed based on genetic algorithms to find optimal PRF sets for any specific application. The space of PRF sets is constrained and is mapped to an unconstrained (lower dimensional) space with one-to-one correspondence. The proposed search technique is employed in the unconstrained space of PRF sets. Such a search is not in general possible in the existing transforms. The optimal PRF sets found by the proposed search technique have been shown to perform better than popular wavelet filters.

S.K. Parui and Y.K. Singh

Speech Analysis and Synthesis

Work on speech was seriously hampered because of unavailability of project – linked worker or research scholar. However, a part of previous work on speech synthesis that was pending last year has been successfully completed. The development of an electronic word – utterance dictionary in Bangla containing about 55,000 words is almost complete. Also, speech data of 400 minutes has been collected from different sources for future analysis.

B.B. Chaudhuri

Postal Automation

Under the externally funded project, entitled "Handwriting recognition for postal automation" funded by Indo-French Centre for the Promotion of Advanced Research (IFCPAR), following work has been done: (a) An improved two-stage binarizing algorithm has been developed to get rid of the inherent noise, advertisement on postal documents, complex background, etc. from the input image. (b) A combined system is developed to recognize pin-code number written in Bangla or English. After extraction of the numerals from the pin-code boxes, a set of 68 features are computed based on water reservoir and other simple techniques. Here though the total number of numerals was supposed to be 20 (10 numerals for English and 10 for Bangla) we have used only 16 classes in the classifier. This is because the English and Bangla 'zero' are similar in shape and we consider these two as a single class. Other three similar shape classes are: English and Bangla 'two', English 'four' and Bangla 'eight', and English 'nine' and Bangla 'seven'. They are taken as same class during classification. A MLP based neural network classifier was used for the recognition (c) A system for word-wise identification of handwritten Bangla and English scripts is developed.

B. B. Chaudhuri, U. Pal and K. Roy

Electronics and Communication Sciences Unit

Bioinformatics

The high dimensional nature of gene expression profiles makes it difficult to identify marker genes for a disease. We have used a novel neural scheme that picks up the necessary features online when the system learns the classification task. The dimensionality reduction and the system identification tasks are done together. Since it considers all features at one go, it does not miss subtle combinations of these features. We demonstrate the effectiveness of our scheme to distinguish between acute myeloid leukemia and acute lymphoblastic leukemia cancer expression data. Our scheme could identify only five genes that can produce as good as or even better results than what is reported in the literature on this data set. It identifies an important marker gene which alone has a very good discriminating power.

We developed an algorithm based on *Linear combinations of Order Statistics* (LOS) operators that constructs dissimilarity measures on pairs of gene products described by sets of terms from the Gene Ontology (GO). Using examples from the GO we showed that LOS measures produced relational data with more (visually apparent) clusters than BLAST-based groupings of the same data. The LOS representations of gene product data are analyzed by both crisp and fuzzy clustering algorithms. The fuzzy partition matrices generated by *Non-Euclidean Relational Fuzzy c-Means* (NERFCM) clustering led to the discovery that two gene products in the data set used might not be properly annotated in the ENSEMBLE database. Revisiting the database, we found that the gene products in question had been reannotated after we collected the data. We also illustrated the ability of NERFCM to extract clusters that seem apparent in visual displays of the LOS dissimilarity data.

N. R. Pal

Pattern Recognition

A new clustering algorithm, named possibilistic-fuzzy-c-means (PFCM) has been proposed which enjoys the benefits of both fuzzy c-means (FCM) and possibilistic c-means (PCM) clustering algorithms. This new algorithm avoids the coincident cluster problem of PCM and reduces the effect of outliers on the cluster centroids for FCM. This algorithm is very suitable for extraction of fuzzy rules for system identification.

An important problem in web-mining is generation of user profiles from web log data. We proposed a *relational mountain clustering method* (RMCM), which produces a set of (proto) typical objects as well as a crisp partition of the objects generating the relation, using a new concept that we call relational density. We then used RMCM for generation of useful user profiles from web log data.

N. R. Pal

Mathematical Morphology

A novel morphological wavelet based algorithm is developed for multi-focused image fusion. In this work multi focussed images are decomposed using wavelets where analysis function is derived from morphological operators.

B. Chanda

Image Compression

Work on image compression is being carried out using vector quantization (VQ). In this method universal codebook is generated using self-organizing feature map (SOFM). Reconstructed blocks are smoothened by surface fitting to improve visual quality.

B. Chanda and N. R. Pal

An algorithm for motion compensation is developed based on hybrid search. This method is essential to reduce inter-frame redundancy for video compression.

B. Chanda

Content Based Image Retrieval

A new measure of colour feature is proposed based on Bhattacharya distance between actual histogram and the expected histogram. A texture feature is computed by means of 2x2 binary pattern derived from the intensity image. A new similarity measure (namely, k out-of n) based on human perception is proposed for the CBIR and its performance is improved by the introduction of relevance feedback mechanism.

B. Chanda

Document Image Processing

An algorithm for table detection is developed and its performance is evaluated over a large database.

B. Chanda

Video Image Processing

Three major aspects of video image processing were targeted during the year. Images of deformable shape were tracked in video image sequence using level set analysis. The proposed approach

involved evolution of an initial closed curve that converges to the shape of the deformable object. Given that a deformable shape can disintegrate to multiple smaller targets as the object is being tracked in a video sequence, the level set based approach could take care of this change in topology of the shape. This kind of object tracking has relevance in applications involving biomedical imaging (e.g. white blood cell tracking), defense applications (e.g. target tracking) etc. This tracking paradigm was also extended to interpolate shape or path that morphs a source contour image to a target contour image. This (missing) shape interpolation is important for applications related to tracking cloud or atmospheric disturbances. In a related development key frames in a video shot are also identified using spatial randomness measure of image features.

D. P. Mukherjee

Detection of Breast Cancer

Of all types of cancer, breast cancer is one of the leading causes of death among middle-aged and old women. Prevention and an early diagnosis of breast tumor and microcalcification are immediate demands from the society. Primary prevention is difficult as the causes of the disease are not well understood. But if it can be detected at its early stage, success rate of survival is quite high.

We have proposed a multi-stage system for the detection of microcalcification from digital mammograms. This system is tested using the MIAS database. A neural network based online feature selection technique is used to select good features. Another neural network is used for detection of microcalcification. The false positive output of the network is reduced using a connected component algorithm. Then an algorithm for removing linear or curve region is applied to get further cleaned image. On that cleaned image we applied a mountain potential algorithm to detect the center of abnormality.

We designed and implemented an algorithm for enhancement of digital mammogram images using human psychovisual facts.

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

Attenuation & Performance Deterioration of Communication Link Due to Rain and clouds

For the requirements of more channels in radio communications system, microwave and millimeter wave frequency (mmwf) bands are in constant demand. The use of IR band frequency will also be in demand in years to come. Moreover, mmwf radiometers on-board satellite are also promising tools for remote sensing. To avoid congestion in UHF and lower region of microwave bands, it has become necessary to use frequency above 10GHz. During the propagation through rain, radiowaves in mmwf bands are subjected to attenuation/deterioration of performance by absorption, scattering, depolarisation, etc. An investigation was made in the coastal region with a 13GHz link where it was observed that the communication link exhibits substantial loss of signal during rains. Further study was made to characterise the cloud morphology for better estimation of radio wave attenuation and it is observed that the attenuation due to cloud increases with the increase in frequency (GHz).

S. K. Sarkar, A. K. De and J. Das

Machine Intelligence Unit

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

The investigation that is currently being done in MIU comprises both the development of these technologies individually and in an integrated (hybridization) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, machine learning, image processing, expert systems, vision, data mining, bio-informatics, etc. related to the design of intelligent systems.

Investigations in certain areas of bio-informatics, case based reasoning, and data mining & web intelligence are now in focus. Hybridization such as neuro-fuzzy, neuro-rough, neuro-fuzzy-genetic helps in making such systems artificially more intelligent.

Note that 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.

Pattern Recognition

The problem of pattern classification is posed as one of optimizing multiple conflicting objectives, viz., the number of misclassified points, the number of hyperplanes, and the classwise scores. Application of multi-objective GAs for evolving a set of classifiers, and using a validity phase (with a specially defined validity functional) for selecting the best classifier from the set, has been described. Domain specific model for incorporating elitism and some new comparative measures have been introduced in this regard.

S. Bandyopadhyay and S.K. Pal

Application of genetic algorithms for partitioning a data set into a variable number of fuzzy clusters has been made. New fuzzy validity measure has been proposed. Application to remote sensing image has been demonstrated.

S. Bandyopadhyay

Sodar or an Acoustic Radar system is a useful tool to efficiently probe the LPBL (Lower Planetary Boundary Layer). The observations obtained by this system can prove to be extremely useful if classified and interpreted correctly. The manual identification of different types of sodar recorded lower atmospheric micro-structures is a laborious task, and can be performed only by an expert having wide experience with the system and the variety of observations recorded by it. We have developed a connectionist system to automatically classify sodar pattern. The results demonstrate that the multiplayer perceptron-based model is capable of successfully identifying the different sodar patterns.

S. Choudhury and S. Mitra

The fuzzy radial basis function (FRBF) network comprises an integration of the principles of radial basis function (RBF) network and fuzzy c-means (FCM) algorithm. A programmable parallel architecture design has been designed for the FRBF, both for FCM clustering at the hidden layer and the weight training at the output layer of the network. The behavior of the system is measured in terms of processor utilization, and its performance quantitatively evaluated.

S. Mitra

Two procedures for aggregating nearest neighbor classifiers have been proposed. The performance of the proposed methodology has been tested on several real life data sets. It has been found that aggregation improves the accuracy of the classifier. The generalization of this procedure for nearest neighbor density based classifiers has also been similarly tested.

C. A. Murthy

Image Processing

New digital watermarking algorithms based on M-band wavelet and M-ary modulation technique have been developed. It has been shown that M-ary modulation along with proper choice of modulation function and signal decomposition tool can greatly improve the data insertion capacity, robustness and imperceptibility of the watermarking scheme. A new scheme based on genetic algorithms for covered image communication with optimal imperceptibility in a noisy channel has been developed. The method is found to be robust against most of the linear and non-linear filtering operation, noise addition, lossy compression and small rotation.

M. K. Kundu

The problem of scarcity of labeled pixels, required for segmentation of remotely sensed satellite images in supervised pixel classification framework, is addressed. A support vector machine (SVM) is considered for classifying the pixels into different landcover types. It is initially designed using a small set of labeled points, and subsequently refined by actively querying for the labels of pixels from a pool of unlabeled data. The label of the most interesting /ambiguous unlabelled point is queried at each step. Here, active learning is explained to minimize the number of labeled data used by the SVM classifier by several orders. These features are demonstrated on an IRS-1A four band multi-spectral image. Comparison with related methods is made in terms of number of data points used, computational time and a cluster quality measure.

B. Uma Sankar and S.K. Pal

Different splines have been used on the gray-level images to examine meaningful features. The recult has shown that these features are helpful in various tasks such as image representation and compression. These spline functions are also being used in neural network models for classification purpose.

S.N. Biswas

Various fuzzy set theoretic and neural based techniques are being developed for change detection in remotely sensed images.

A.Ghosh

The problem of parameter selection in edge detection has been addressed. A way of standardizing the edge magnitudes in gray level images using statistical principles has been proposed which resulted in the same parameter values for finding edge maps in all the images. The results on real life images have been found to be better than the results of other edge detection methods. This procedure has been generalized to color images and the corresponding edge maps have been found to be better than the edge maps obtained by other edge detection procedures.

A hue preserving contrast enhancement procedure for color images has been developed. It generalizes any gray level enhancement technique for color images. Thus a hue preserving histogram equalization technique has been developed.

Two methods for object recognition in color images have been developed. These methods initially provide features for objects. Later these features are compared to find close matches for objects. The suggested procedures provided better recognition rates than the earlier methods when one, two, or four views are considered for the objects. The results have been demonstrated on SOIL and COIL data sets.

C. A. Murthy

Web Intelligence and Data Mining

A new stemming method is proposed which incorporates sequential hypothesis testing to minimize the ambiguity resulting from stemming.

A novel surfer model that probabilistically incorporates the history of a surfer to obtain the transition probabilities of the surfer has been developed. This model has been shown to be useful for various web-mining tasks like web page ranking, categorization and topic sensitive page ranking. This is an extension of the intelligent surfer model, and may be looked upon as the integration of text and link analysis.

S.K. Pal

Case Based Reasoning

A novel rough set-based reasoner for use in text categorization (TC) is developed. It has four main components: feature term extractor, document representor, case selector, and case retriever. It operates by first reducing the number of feature terms in the documents using the rough set technique. Then, the number of documents is reduced using a new document selection approach based on case-based reasoning (CBR) concepts of coverage and reachability.

A novel approach to build efficient and competent CBR classifiers that combine feature reduction (FR)

and case selection (CS) is developed. The research work makes three central contributions: (i) to compute the approximate reduct, it develops a fast rough-set method that makes use of relative dependency among features, (ii) it constructs and compares different case selection approaches that are based on the similarity concept, (iii) by building CBR classifier using a combination of the FR and CS processes, it develops an approach which can reduce the training burden as well as the need to acquire domain knowledge.

S.K. Pal

Bioinformatics

A technique for extracting features from protein sequences that incorporates the positional information of the amino acids was developed. Its effectiveness in protein superfamily classification was studied. In this context, a recently developed genetic fuzzy clustering method was utilized for first extracting prototype sequences from superfamilies, and then performing the classification based on the nearest neighbor rule. This resulted in significant gain in computational time, as compared to other alignment-based techniques like BLAST, while the classification performance was found to be comparable. In the domain of drug design, a variable string length GA based technique for ligand design was developed, and its real life utility was demonstrated by comparing with known structures from the Cambridge Structural Database (CSD).

S. Bandyopadhyay

Some methods of extracting genetic regulatory networks from time series gene expression data are being developed in connectionist framework. The methodology includes modeling gene expression data using linear differential equation, followed by extracting sparse connectivity matrix indicating interactions of various genes. In addition, the issue of organizing various data related to molecular biology in a suitable database for a particular organism will be investigated. Reconstruction of metabolic pathways is under investigation. The methodology includes flux balance analysis and graph theoretic approach.

R.K. De

Critical surveys on the application of artificial neural networks and evolutionary computation are made to different bioinformatics problems. Relevance of their integration is also explained.

S. K. Pal and S. Bandyopadhyay

Genetic Algorithms, Rough sets, Artificial Neural Networks and Soft Computing

New genetic operators have been developed for solving hard permutation problems like the Traveling Salesman Problem. Application to microarray data is being investigated. An improved model of multiobjective GAs that incorporates a new domination distance factor has been developed. Comparison with several well-known techniques has demonstrated the superiority and robustness of the proposed method. Another model of multiobjective simulated annealing has been developed. Preliminary results are encouraging.

S. Bandyopadhyay and S. K. Pal

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)

R.K. De

An evolutionary rough c-means clustering algorithm has been designed. Genetic algorithms are employed to tune the threshold, and relative importance of upper and lower approximations of the rough sets modeling the clusters. The Davies-Bouldin clustering validity index is used as the fitness function that is minimized while arriving at an optimal partitioning. A comparative study of its performance has been made with related partitive algorithms. The algorithm performs well on real and synthetic datasets, including microarray gene expression data from Bioinformatics.

S.Mitra

A definition of rough entropy of an image is provided. Its significance in image segmentation is demonstrated.

S.K. Pal and B. Uma Sankar

A rough self-organizing map (RSOM) with fuzzy discretization of feature space is described. Discernibility reducts obtained using rough set theory are used to extract domain knowledge in an unsupervised framework. Reducts are then used to determine the initial weights of the network, which are further refined using competitive learning. Superiority of this network in terms of quality of clusters, learning time and representation of data is demonstrated quantitatively through experiments over the conventional SOM.

S.K. Pal

Physics and Earth Sciences Division

Geological Studies Unit

Research and other Scientific Activities

Project:

Precambrian Geodynamics in East Indian Shield

Collision generated shear zone at western margin of Eastern Ghats mobile belt has been established with implications for rapid exhumation of the granulites. Collisional granites at the northern margin of the Eastern Ghats mobile belt, has been described, with evidence from geochemical and microscopic fabrics. Crustal source of a syenite complex in the Eastern Ghats mobile belt, has been established with geochemical and Sm-Nd isotopic evidence.

S. Bhattacharya and Amit K. Shaw

DST Project: Mafic crustal xenoliths: a window to mantle dynamics

Two types of cognate xenoliths, prograde hornblende-bearing and prograde biotite-bearing respectively, within massif-type charnockite, have been identified from four sectors, Chilka, Jenapore, Sunki and Naraseraopet, in the Eastern Ghats belt.

S. Bhattacharya and P. Das

Tectonic setting of the Alkaline complexes in the Eastern Ghats belt

Koraput Alkaline complex has been described as emplaced in a pull apart structure, synkinematically with F_2 deformation in the country rocks. Petrological and geochemical evidence suggest differentiation of an Alkali-basalt series.

S. Bhattacharya

Evolution of the Nallamalai fold belt – fault reactivation and kinematics

Tentative plate-tectonic reconstruction for the post-Kurnool (Pan-African) evolution of the Nallamalai fold belt (NFB) and Nellore schist belt in relation to the Eastern Ghats belt (EGGB) has been put forward based on structural asymmetry and re-assessment of geological and geophysical data. It is postulated that that an oceanic domain ahead of south Indian craton was subducted beneath east Antarctica in the late Neoproterozoic. An older deformation in the NFB, proto-NSB and evolution of the EGGB is possibly related to late Mesoproterozic collapse of an arc/ocean island that existed prior to amalgamation of EGGB-Rayner complex combine to East Antarctica.

D. Saha and S. Chakraborty

Calcite fabric and deformation kinematics

Both shape fabric (SPO) and crystallographic fabric in calcite aggregates are important in modelling upper crustal deformation kinematics, for paleostress estimates and as a strain gauge. New substantive data from Palnad have been analysed to demonstrate an inverse relation between

inclination of oblique grain shape foliation and incremental strain in dynamically recrystallized grains in calcite mylonites with grain scale S-C fabric. The asymmetry of calcite *c*-axis fabric is consistent with obliquity of calcite SPO and footwall deformation induced by westward thrusting in the Nallamalai fold belt. Grain shape modification is sensitive to moderate strain variation in calcite mylonites in a low-temperature regime.

D. Saha and S. Chakraborty

Proterozoic basin analysis: Chattisgarh and Pranhita Godavari Valley basin

Reconstruction of lithostratigraphic succession in the eastern part of the Neoproterozoic, Chattisgarh basin indicates the presence of two unconformity- bounded sequences. The lower sequence consists of a coarse siliciclastic assemblage overlain by a limestone-shale dominated assemblage deposited within a number of transgressive-regressive cycles of different order. The sequence was terminated with basin uplift and renewed rifting associated with felsic volcanism and deposition of welded tuff and volcaniclastic sandstones. The upper sequence starts with a red conglomerate-sandstone with clasts of underlying felsic volcanics. The upper part of the sequence has been truncated by a fault zone that delineates the northern and eastern limit of the eastern Chattisgarh outcrops. The Chattisgarh unconformities, possibly of inter-regional character, can be correlated with those in the Pranhita–Godavari Valley, at the base of the lower Neoproterozoic Penganga Group and the upper Neoproterozoic Sullavai Group, respectively.

S. Patranabis-Deb and A. K. Chaudhuri

Mesozoic tetrapods from the Satpura and Pranhita-Godavari basins

In the Satpura Godwana basin of central India, a large number of archosaur bones have been collected from a new site within red mudstone of the Middle Triassic Denwa Formation at the western part of the basin. Laboratory preparation of these new materials is in progress and the preliminary identification indicates the presence of an erythrosuchid and a rauisuchid. During last field season, a large chigutisaurid amphibian skull measuring about 65cm x 60cm has been unearthed from the Late Triassic Maleri Formation of the Pranhita-Godavari valley in south-central India.

A critical review of earlier collected and described theropod dinosaurs from the Late Cretaceous Lameta Formation of Jabalpur demonstrated that these theropod elements belong to a single theropod clade, the Abelisauroidea.

Analyses of a new rare temnospondyl amphibian family, collected from the Denwa Formation, along with its functional aspects have been completed.

D.P. Sengupta and S. Bandyopadhyay

Morphometry of temnospondyles

Shape analysis of temnospondyl skulls illustrates a scheme of quantitative description of the skull outlines using bilaterally symmetric closed Fourier curves. The model takes into account the entire arc length of the skull outlines and grades them according to their shapes.

D.P. Sengupta, P.S. Ghosh and D. Sengupta

Lystrosaurus bone histology

Bone microstructure of the early Triassic dicynodont, namely *Lystrosaurus murray*, from India and South Africa have been examined which revealed predominance of fibrolamellar bone tissues suggesting rapid periosteal osteogenesis and an overall fast growth in this group. Moreover four distinct ontogentic stages have been identified in these forms and an indeterminate growth strategy and a semi-aquatic lifestyle for *Lystrosaurus murrayi* has been suggested.

S. Bandyopadhyay and others

Sedimentology and palaeoclimatology of Satpura upper Gondwana

The overwhelming proportion of mudrock in the Triassic Denwa Formation is inexplicable in terms of regular overbank flooding of river. These mud-dominated heterolithic extrachannel deposits are found to be crevasse splay/avulsion deposits in a semi arid climatic setting.
Petrographic analysis of the litho- and pedofacies of the Permo-Triassic succession reveals increasing aridity with time. Moreover, the results also suggest events of unearthing of newer source rocks and reworking of sediments within the depositional systems.

S. N. Sarkar, P. Ghosh, P. K. Maulik and T. Chakraborty

Micellar and microemulsion systems

Solubilization behaviour of both water and electrolyte in mixed surfactant reverse micellar systems in three oils has been studied. The enhancement in water and electrolyte solubilization (i.e. synergism) has been evidenced in most of the systems, and maximum values have been reached as a function of mole fraction of the nonionic surfactant and (electrolyte). The temperature induced solubilization of water (in presence and absence of additives) for AOT blended with nonionic surfactants in IPM oil at different compositions has also been investigated. The solubilization behaviour and stability of these systems with respect to temperature have also been found to be influenced by the content, configuration of the polar head group and the hydrophobic moiety of the nonionics. The energetic parameters of the desolubilization process of water (or electrolyte) in these mixed systems have been estimated. The occurrence of ω-induced or temperature-induced percolation in conductance with the corresponding threshold values (ω_p or T_p) has been explained to unravel the solubilization process and the microstructure of these systems. The effects of water content (ω), micelle concentration, content of nonionics ($X_{nonionic}$), additives and oils on the percolation phenomenon have been explained. Activation energy (E_a) of the percolation process (in absence and presence of additives) has also been estimated. The phenomenon of percolation of conductance in these systems has been rationalized for the first time utilizing all these parameters.

B. K. Paul and R. K. Mitra

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

The field observations in the Northern West Bengal and parts of Sikkim and Assam indicate rapid riverbed aggradation in Jayanti, Pana, Pagli and Jia Bharoli Rivers. Whereas, many of the upstream reaches of the fluvial systems and associated tributary fans are characterised by rapid incision. Field observations on the deformations of terraces of the Murti, Neora and Kurti Rivers of the Chalsa region, WB and the analysis of the geomorphic surface of that region revealed the presence of apparently dormant fault zones that had affected the Sub-Himalayan Quaternary alluvium of this region. Remarkable differences in the sediments of the older and younger terraces also reveal tectonic and climatic changes during the last ten thousand years.

On the other hand, an indigenous computer simulation has been developed that simulates large-scale movement of water forming river channels over a digital three- dimensional topographic surface. The algorithm, based upon the principles of cellular automata, considers the topographic surface as a collection of discreet adjacent cells and simulates transfer of water to neighbourhood cells by changing the relative water levels. Water is transferred depending on the relative topographic heights and water levels of the cells in a manner to maintain the temporal continuity of water transfer both in terms of direction and amount. The rainfall on the topographic surface is simulated by independently increasing the water levels of the cells. This simulation also includes interfaces for realistic application of this simulation, e.g. to make local changes in topography representing dams, embankments, canals, tectono-geomorphic changes, etc.). We have tested this simulation for a part of North Bengal (near Torsa River) and noted that this simulation generates realistic river channels that respond to topographic and rainfall changes. We hope that this simulation will help to predict the natural flood events of this region. However, the accuracy of the simulation results depends heavily on the quality of the topographic and rainfall data.

P. Ghosh and T. Chakraborty

Physics and Applied Mathematics Unit

Research and other scientific activities

Physics

Condensed Matter Physics

The discovery of Berry phase in 1984 spurred intense theoretical efforts to work out implications in many areas of contemporary physics. It is a special type of phase that a particle acquires solely from geometry, if it is forced to slowly rotate. This phase has topological origin when studied from the quantum field theoretical point of view. Topological quantum phases are crucial in explaining many effects in the new field of mesoscopic physics, (where tiny electronic circuits exhibit quantum behavior such as superconductivity, the quantum Hall effect, the Josephson junction, flux quantization, anomalous Hall effect and many others). Studies in some of these interesting effects in terms of Berry phase are being carried out.

The newly observed families of fractional quantum Hall (FQH) states are studied in the framework of Berry phase and it is shown that they are well accommodated in the primary sequence of FQH states and need not be considered as second generation states.

The Berry phase formulation is used to describe the propagation of charge carriers in a spin fluctuating background in the underdoped cuprates (an example of high temperature superconductors) and it is shown that the superconducting pairing is due to the formation of skyrmion-skyrmion bound state.

Study on a deep connection of Berry phase with another interesting quantum phenomenon, viz. Entanglement has been done. It is shown that in a spin system the concurrence (measure of entanglement) can be written in terms of the Berry phase. Besides, in the study of quantum phase transition problem entanglement is found to be responsible for the development of the long-range order at the critical point. These works are done in collaboration with Prof. P. Bandyopadhyay, (former) Professor, PAMU.

B. Basu

A simple model of quantum Hall systems where the Coulomb interaction has been taken into account has been suggested. This can simulate the bi-layer quantum Hall system in the lowest order of perturbation. Extension of these ideas in NC space has also been examined.

B. Basu and S. Ghosh

Quantum mechanical analysis of motion of rigidly confined (in 2-dimension) electron (circular quantum well) in a perpendicular magnetic field. A collaborative work has just started with Dr. P. Singha Deo of S.N. Bose National Centre for Basic Sciences (SNBNCBS).
A general mathematical analysis of the Fock-Darwin spectrum (electronic states and energy levels) in case of parabolically confined electron in 2-dimension acted upon by a perpendicular magnetic field has been done. Some extensions of this work will be done in collaboration with Dr. P. Singha Deo of SNBNCBS.

A.K. Roy

Classical Optics

Inverse scattering problem in optics involving Mie particles is being studied. The extinction spectrum generated by various spherical particle size distributions (Gaussian, Beta, Gamma) has been analysed mathematically as well as numerically. The work is being done in collaboration with S. K. Sharma, SNBNCBS.

A practical problem relating to the constriction of the (scattering) phase function for a bio-medical tissue is undertaken in collaboration with S. K. Sharma.

An investigation to understand the physicalities of the generalised Snell's law is in continuing.

A. K. Roy

Foundation of Quantum Mechanics

The theory of weak value measurement is under investigation in the context of quantum information and quantum computing.

The concept of pregeometry and probabilistic geometry has been proposed to understand the physics at Planck scale. New decomposition theorem is under investigation at sub-Planck scale. Collaborators of this project are Professor M. Kafatos, Dr. J. Tollaksen, George Mason University, USA and Professor M. Requardt, Germany.

S. Roy

Quantum Information & Entanglement

No-go theorems in quantum mechanics like no universal Hadamard gate, no flipping, no deleting are being studied in the context of no-singling condition and no increase of entanglement by local operation and classical communication.

The peculiar feature of quantum entanglement gives rise to remote state preparation which is being studied for more complicated system like qudit and using dark state. Probabilistic dense coding has been currently studied using non-maximally entangled state. Another interesting line where investigation is going on is discrimination of orthogonal bipartite pure entangled states by local operation and classical communication.

New proofs of impossibility of replacing quantum mechanics by Local Hidden variable theory are being investigated for higher spin with the aim of applying them in the newly developed area of quantum communication complexity.

G. Kar and P. Parashar

Quantum Field Theory

Non-Commutative Quantum Field Theory (NCQFT): Recently NCQFT has emerged as an area of intense activity in High Energy Physics. The NCQFT appears in certain limits of String Theory in the presence of background field, in the Open String boundaries, connected to d-branes. Work is being done on various aspects of NCQFT.

Various NCQFTs in *2+1*-dimensions have been studied from different perspectives. Soliton-like structures appearing in an NC extension of the *CP (1)* and Chern-Simons-Higgs models have been studied. These are distinct from the NC extensions of solitons so far studied. The subtle nature of Lorentz invariance violation in NC gauge theories has been elaborated in the Hamiltonian framework. We have constructed the inter particle Coulomb potential in NC Maxwell-Chern-Simons theory coupled minimally to scalar or spinor matter. It has been shown that NC effects induce a Pauli magnetic coupling term and can lead to Cooper pair like bound states. At present, the potential at the one loop level is being studied with Professor Rabin Banerjee and Mr. Sourobh Samanta of S. N. Bose National Centre for Basic Sciences, Kolkata.

The operatorial forms of NC spacetime, such as the *k*-Minkowski or Snyder spacetimes are constructed from constrained dynamics of particles in relativistic and non-relativistic framework. In the *k*-Minkowski case, the low energy limit yields a novel type of oscillator. Generalization of these models to reparameterization invariant String and Brane models is being studied. These works are being done in collaboration with Dr. Probir Pal, Uluberia College, West Bengal.

S. Ghosh

Modified Newtonian Dynamics & Cosmology

The model of vacuum as proposed by Requardt has been used to estimate the constant in MOND. The cosmological implications are under investigation. This project is collaboration with Dr. F. Rothwarf, USA.

S. Roy

Astrophysics

Dynamic Multiple Scattering (DMS) has been developed by Roy et. al. to explain the shift of the wavelength as well as the broadening of the spectral line during the propagation of electromagnetic wave in turbulent and in homogeneous medium. This is due to the induced correlation effect as proposed by Wolf. This plays significant role in Quasar astronomy and discordant redshift. The results of our framework are under the process of verification in laboratory by Kandpal et. al., NPL, New Delhi.

S. Roy

Symmetries in Quantum Mechanics

We have made comprehensive study of PT-symmetric systems. It has been shown that certain isospectral systems are related by a PT-symmetric generalisation of supersymmetry (susy) called pseudo supersymmetry. We also studied in detail the possibility of using second order Darboux method to PT-symmetric models and it has been shown that such systems have second order pseudo susy as the underlying symmetry. A formalism is developed to obtain isospectral partners of complex PT-invariant potentials using second order intertwining operator. Intertwining operator method has also been applied to effective mass models to obtain isospectral partners of solvable potentials. A group theoretic approach to Schrödinger equation with position dependent mass is being studied.

P. Roy, B. Roy and R. Roychoudhury

Theoretical Plasma Physics

A new technique has been developed to study non-linear waves in Dusty Plasma and Plasma in electromagnetic field. This will be useful for studying different kinds of solitary waves including double layers in astrophysical plasma. Recently Cylindrical and Spherical KdV and modified KdV equations have been derived for Dust Ion Acoustic Waves. Also some exact analytical solutions are obtained for these nonlinear equations. Recently dust acoustic solitary waves were studied using gas dynamical approach. This approach will be extended to the cases of plasmas in electromagnetic field.

R. Roychoudhury

High and Ultrahigh Energy Physics

The puzzles of quark-gluon plasma diagonostics from the CERN-SPS experiments and the BNL-RHIC experiments have constituted our prime interest and concern. Besides, some other aspects of High Energy Physics, especially the nature of elastic, inelastic differential cross sections and the total cross sections have also drawn our attention. With a non-standard and alternative approach to the former, we have so far catered to an extensive set of rich available data from the latest experiments. A lot more still remains to be done in future, especially on those emanating from the future Large Hadron Collider (LHC) which is to start operation circa 2007.

S. Bhattacharyya

Interacting Fock Space

Interacting Fock Space provides a natural framework to describe a large class of self-interacting quantum field theories (nonlinear) analogous to that played by usual Fock Space for non-interacting fields (linear theories). A study of coherent states and squeezed states and their phase distributions have been obtained. Quasiprobabilities in the space are under observation and the theories will be applied to study two-level and three level atoms.

P.K. Das

Fluid Mechanics and Applied Mathematics

Basic Fluid Flows

Industrial fluid mechanical problems are modelled with a view to understand the physical processes involved in their respective applications. On spin coating process, it is found that while the inertia of liquid decelerates film thinning, the non-uniformity of the disk gives the same rate of film thinning as

the planar one. It is also observed that the profile of the liquid film eventually becomes similar to the shape of the rotating disk.

To study the heat transfer on a stretching sheet either due to suction or injection, two types of heat transfer conditions are imposed on the sheet (i) with prescribed surface temperature and (ii) prescribed wall heat flux. Exact solutions for both the temperature distributions in terms of Kummer's functions are obtained.

B.S. Dandapat

Hydrodynamic Stability and Waves

Stability characteristic of a thin conducting liquid film flowing down, on a non-conducting plane in presence of electromagnetic field is investigated under the assumption of small magnetic Reynolds number. Surface evolution equation is derived by using long-wave approximation method. Linear and non-linear stability analysis of the evolution equation shows that magnetic field stabilizes the flow whereas electric field stabilizes or destabilizes the flow depending on its orientation with the flow. It is also found that both the subcritical instability and supercritical stability are possible. Further subcritical and supercritical zones vanish for large Hartmann number, so long electric parameter is small.

B.S. Dandapat

Turbulent Boundary Layer Theory and Applications

Wall bounded flows of Newtonian and non-Newtonian fluids are often encountered in natural situations and in engineering practices. Since, the construction of the turbulent boundary layer, based on mixing length concept by prandtl, innumerable attempts have been made to generalize this theory and to solve practical problems. But most of the theories on turbulent boundary layer are based on empirical considerations. In the present scheme, we would be working within the framework of the first principles of fluid mechanics and some physically plausible assumptions. Appropriate models are to be developed for the turbulent flows through pipes, channels, etc. Besides, the structure atmospheric boundary layer and the problems of hydraulics under various physical conditions are to be investigated.

H.P. Mazumdar

Dynamical Systems and Chaos

Modelling of various physical problems by dynamical systems is of considerable importance at the present time. Applying the leading singularity method, integrability condition of some dynamical systems including the ones like Rössler and Sherman systems are to be investigated. Behavior of the components with time and the related structures in phase-space are also to be studied.

H.P. Mazumdar

Water Waves

Water wave scattering by two nearly vertical barriers, the barriers having a number of basic geometrical configurations, has been studied by using a perturbational analysis. The first order reflection and transmission coefficients are obtained by employing Green's integral theorem in a suitable manner.

Problems of interaction of water waves and ice-cover modeled as a thin elastic plate, have been investigated by reducing them to the solution of coupled Carleman type singular integral equations, which are in turn reduced to Riemann Hilbert boundary value problems of complex variable theory.

Motion in water with an ice-cover due to various types of sources, due to ground motion and due to disturbances at the ice-cover, is being studied by employing appropriate mathematical techniques.

Introduction of water waves and obstacles of various geometrical configurations present in water with an ice-cover is being studied starting with an obstacle in the form of a long cylinder submerged in ice-covered water.

Water wave scattering by bottom undulations in ocean with an ice-cover and in ocean modelled as a two-fluid medium with upper medium having a free surface as well as an ice-cover is being investigated by a perturbational analysis followed by Green's integral theorem to obtain the reflection and transmission coefficients approximately.

B.N. Mandal

Integral Expansions

Singular and hypersingular integral equations having relevance to problems arising in the linearised theory of water waves and fracture mechanics are being studied for exact as well as approximate solutions. Also coupled Carleman type singular integral equations arising in wave-ice interaction problems are being studied for approximate solutions.

B.N. Mandal

Convective and Diffusive Transport

Transport of dissolved/non-dissolved substances due to the shear effect of current has been studied numerically in oscillatory laminar/turbulent boundary layer flows. This study provides the basic mechanism of dispersion of contaminants in open-channel flows relevant to river geometry, estuaries or tidal basins. Dispersion of contaminant is important not only to the physical process of matter transport, but also to the biological processes of birth and growth of planktonic larvae in the sea.

B.S. Mazumder

Interdisciplinary Research

Quantum Coherence & activities of Ion-channels in the Brain

The recent observation of ion-channel activities raised a lot of excitement : whether they can be explained by quantum mechanical formalism or, in other words, quantum mechanics is at all applicable to Biological system. We have proposed that conservative diffusion process can explain the behaviour of the movements of the ions within the channels. This will shed new light on quantum entanglement, quantum information, etc. Collaborative scientists will be from USA and Austria.

S. Roy

Sedimentological Fluid Dynamics

Interdisciplinary research work to understand the basic mechanism of sediment transportation and deposition involving fluid dynamists, statisticians and geologists has been carried out theoretically as well as experimentally in a hydraulic flume at ISI Calcutta. Turbulent-particle interactions, combined wave and current and its impact on sediment transport, development and evolution of bed forms due to wave-current interactions are the main theme of the work. To investigate the turbulence characteristics of flow which are responsible for transporting the sediments, continuous recording of all three turbulent velocity components with fluctuations have been carried out using 3-D Micro Acoustic Doppler Velocimeter (ADV). The High Speed Motion Scope system (maximum 500fps) available in the Laboratory of Physics and Applied Mathematics Unit of ISI, Calcutta, is used to catch the photographs of the movement of granular particles of different sizes at the near-bed boundary layer under the controlled flow conditions. The Image Pro-Plus (IPP) is applied to the photographs to understand the speeds and mode of motion of the particles during displacement, trajectories, rotation and their interactions with the boundary layer.

B. S. Mazumder

System and Control Theory

The area of interest is to develop numerical methods for analysis, design and development of multivariable control systems. An attempt will be made to design observer for matrix second order system. Work will be done on analysis and stability for nonlinear dynamical systems.

S.Gangopadhyay

Linguistics-Mathematics Interface

As every human being can create infinite set of sentences out of finite set of words, the immediate aim of contemporary linguistics is to understand the mechanism or algorithmic principles and parameters behind such human computation by deploying the tools of simple algebra. Keeping in mind this principle, we are investigating the following domains in our research:

The computational system of language in special reference to Bangla: a valency-based system is developed to analyze Bangla sentences.

The mismatch between human computation and technological computation with special reference to Godel's Theorem and Fuzzy logic.

Analogous deployment of syntactic model in understanding of DNA-sequences in the codon-region. Indian Logico-Mathematical tool is used to understand deletion-erasure phenomena in sentences.

Musical notes and their proportionate distribution in an octave are used to understand intonation pattern of human speech. The future goal is to simulate this pattern in the machine.

In case of methodology, all these projects follow the pluralistic path or theory of manifold perspectives (n-nary system) and possibilities instead of binary operating system.

D. Bandyopadhyay

Biological Sciences Division

Agricultural Sciences Unit

Research and other Scientific Activities

Ecological and physiological studies on the mangroves of Sundarbans

Sundarbans is the second largest mangrove vegetation in the world. The Indian part consists of 4264 sq. km. The rate of photosynthesis, transpiration, stomatal conductance, leaf temperature, ambient temperature and photosynthetic active radiation (PAR) were measured using a Photosynthesis system (CI-301PS, CID, Inc., USA). Standard laboratory methods were used to estimate osmotic potential of leaves and roots, free amino acids, proteins, soil and water analysis. For the study of community structure and biomass estimation, statistical sampling methods were applied to design and determine the optimum shape and size of quadrat, which showed a 4m x 16m as the optimum size. Structural indices such as specific density, relative frequency, relative density, relative dominance and importance values were calculated using standard methodology.

M. Ghose, S. Das, P.K.Ghosal, K. Bhattacharya,
P. Nandy, Hema Joshi and T. Kumar

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

The rattan palms (*canes*) form one of the most important Non Timber Forest Products (NTFPs) and play an important role in the socio-economy of forest dwelling communities of the Northeast. Extensive survey conducted in the three districts of the Barak Valley region of Assam, has revealed the existence of nine species of canes, which included some rare and very rare species, and needed to be conserved immediately through both in-situ and ex-situ methods. Mature seeds of *Calamus tenuis* were collected and their mode of germination were studied and it was found that germination of seeds was almost 100% if the pulp of the fruits was removed before sowing. The soil variables governing the occurrence of species of *canes* were further studied. The species showed distinct differences in their soil characterization and ecological requirements such as pH, conductivity, bulk density, micronutrient content and texture, etc.

M. Ghose, S. Das, K. Bhattacharya, Sanjay Das
and Abhik Gupta (Assam University, Silchar)

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

Composting is one of the oldest and simplest methods of organic waste stabilization. It is a self-heating solid biodegradative process. To obtain a better understanding of microbial diversity in the composting process, different methodologies were adopted :

Traditional microbiological techniques
Molecular Biological techniques

The advent of PCR has revolutionized microbiological ecological studies. It amplifies 16S rDNA, a phylogenetic marker that is helpful in identification of microbes. Fluorescence in situ hybridization (FISH) with rRNA tagged oligonucleotide probes facilitates the rapid and specific identification of individual microbial cells in that natural environment. Fieldwork related composting studies were carried out in Gupta Nivas Field site (ISI Farm).

A study was made to get an idea of the cultivable and non-cultivable cell count of all stages of composting samples. Samples were prefixed in 4% Paraformaldehyde and spotted on coated slides and stained with DAPI. After vigorous washing and air-drying the cells were observed under epifluorescent microscope.

The following molecular biological techniques were adopted:

A. Isolation of chromosomal DNA from *E.coli*
B. Transformation of *E. coli* strain with Blue Script Plasmid (pBS)
C. Plasmid isolation by quick lysis
D. Fluorescence in situ hybridization

Additionally, total viable cell count of compost was done. Some characteristics of the raw materials used in the composting were also noted. Culturable microbes screened during composting were the representatives of *Bacillus*, *Xanthomonas*, *Streptomyces*, *Thermomonospora* and *Aspergillus*.

S. Chanda, S. Barik and Subrata Pal (Jadavpur University)

Mathematical ecology and epidemiology

The dynamics of a rapid (or massive) increase or decrease of plankton populations is an important subject in marine plankton ecology and generally termed as a 'bloom'. Harmful algal blooms (HABs) have adverse effects on human health, fishery, tourism, and the environment. In recent years, considerable scientific attention has been given to HABs. Toxic substances released by harmful plankton play an important role in this context. We studied this problem by analysis of a mathematical model consisting of two harmful phytoplankton and zooplankton. The analytical findings have been verified through experimental observations, which were carried out on the eastern part of Bay of Bengal for the last three years.

Coexistence of a large number of phytoplankton species on a seemingly limited variety of resources is a classical problem in ecology, known as 'the paradox of the plankton'. Strong fluctuations in species abundance due to the external factors or competitive interactions leading to oscillations, chaos and short-term equilibria have been cited so far to explain multi-species coexistence and biodiversity of phytoplankton. However, none of the explanations has been universally accepted. By analyzing the field-collected samples of marine plankton population we have introduced a new mechanism for regulation of the dynamics of plankton. The findings have been demonstrated through qualitative analysis of sample data and by analysis of a mathematical model. It has been found that so called planktonic non-equilibria' is due to switching of dynamics through irregular fluctuations, limit cycle oscillations and fragile-stable state. This offers a novel solution to the plankton paradox governed by the activity of toxin-producing phytoplankton (TPP).

J. Chattopadhyay

Ponds, aquatic weed and water quality

The study explores the causes of phytoplankton dominance/disappearance and/or macrophyte dominance/disappearance in small water bodies like ponds, which are widely used by local people for various activities pertaining to daily life. Monthly sampling of twelve ponds (six of each type - macrophyte dominated ponds and algal bloom ponds) for a number of water quality parameters (temperature, pH, Secchi depth, total kjeldahl nitrogen, nitrate nitrogen, total phosphorus and chlorophyll-*a*) is being routinely done. From the data collected so far, the algal bloom ponds were found to have more phosphorus, total kjeldahl nitrogen and chlorophyll-a as well as lower Secchi depth visibility compared to the macrophyte-dominated ponds. The species number in the macrophyte dominated ponds varied from 3 to 7 while the blooms in the phytoplankton dominated ponds comprised mainly blue green and green algae.

A.Dewanji, C. Meoda, S. Chatterjee, L. Magranti, G. Mukherjee and S. Sengupta

Studies on productivity, stability and sustainability of rainfed agricultural systems in the eastern plateau region

Low input technologies that are eco-friendly and well suited to eastern plateau region having potential towards increasing and stabilizing productivity were evaluated and transferred to the farmers. The objective is to maintain livelihood through subsistence farming in the risk prone fragile ecosystem of the study area. Field trials 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. New yet value added crops (like baby corn) are also being tried to be established in this area with appropriate package and practices. The improved low input technologies are being diffused to farmers' field through 'on farm' trials. This year experiments are being conducted on farmers' plot in 8 villages of Giridih district, Jharkhand. Studies were conducted to minimize the uncertainties associated with rice farming and to induce sustainability in rice agriculture in the region; rice area characterization helped to identify the appropriate time and space for rice cultivation and thereby to increase the productivity.

P. Banik, P.K. Ghosal, T. Sasmal, K. Bhattacharya,
B. Sarkar, N. Mahato and P. Pramanik

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

Azadirachta indica (Meliaceae), popularly known as neem, has great reputation in Ayurvedic medicine for the treatment of liver disorders. But no systematic investigations have so far been reported regarding its action on liver.

Our findings revealed that water-soluble portion of alcoholic extract of leaves of neem possesses significant antihyperglycemic, anti serotonin, anti inflammatory, hypotensive, antifertility and hypolipidemic activity but also has significant hepatoprotective activity against paracetamol induced hepatic damage in rats. The values of serum enzymes were much lower in case of animals receiving neem leaf extract and paracetamol than those given paracetamol alone indicating that the degree of hepatic cell damage was of lesser magnitude in neem leaf extract treated group. Histology of liver obtained from group of animals receiving paracetamol and saline showed wide areas of frank necrosis of liver parenchyma and a picture of dilated vasculature and sinusoids around the necrotic zones. On the other hand, the hepatic histology in the group receiving both the leaf extract and paracetamol showed little deviation from that seen in an otherwise normal animal. From these findings it can be inferred that neem leaf extract possesses significant hepatoprotective activity against paracetamol induced hepatic damage in rats. The neem leaf extract on different biochemical, haematological and enzymatic parameters were studied against paracetamol induced hepatic damage in rats and it was found that the hepatoprotective activity of neem leaf extract was due to its antioxidant activity. Chemical analysis revealed that the extract contains a mixture of six flavonol-O-glycosides. It is presumed that these glycosides either wholly or partly may be responsible for this activity.

R.R. Chattopadhyay

Innovative biopesticidal efficacies of lower and higher plants

Controlling store grain pests and aphids is considered to be the major challenge in the realm of applied agricultural entomology. Store grain pests thrive on the grains of human consumption. Application of chemical pesticides is out of question, because of their serious side effects.

Recent finding from Heidi et. al., suggesting that several store grain pests' genomes can acquire genomes from other species adds to this challenge a time factor based development of resistance, which was earlier ignored by several researchers. Plant (both lower and higher) derived molecules are now thought to be the best alternative in this kind of complicated situation because of their low mammalian toxicity, cross reactivity with human genomes and cost effectiveness.

With active collaboration from Humboldt University, Berlin, Germany and Central Research Institute, Kolkata, a large number of lower plant derived (e.g., diatomaceous earth particles from phytoplankton or DE) and higher plant (e.g., *Ocimum sp.*) derived molecules were screened last year for their efficacy against store grain pests and aphids. Few lead compounds have turned out to be highly effective against specific insect. We have been able to demonstrate at the molecular level that *Ocimum* causes down-regulation (like Go/11) and up-regulation (like Gs) of G proteins. A large number of datasets gathered from behavioural studies, laboratory trials and molecular work would be used to compute various mathematical and statistical models in prediction of the field trial efficacy and genetic characterisation of the insect at the molecular level.

A.Goswami, S. Adhikary, A. Bhattacharyya (Vidyasagar College), C. Ulrichs (Humboldt University, Germany

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

The Unit has been doing research work on sugar beet (*Beta vulgaris* L.) crop from early nineteen eighties. Out of many remarkable findings from our earlier experiments, one of the most important findings was proper balance of fertilizer K along with N, which can check the falling trend of sugar concentration of sugar beet crop. A good quality and quantity of pectin as a by-product can also be obtained after extraction of alcohol through solid-state fermentation from beetroot. Earlier experiments on different varietal performance showed that out of thirty varieties at least 8-10 varieties can be compared with the standard variety *Ramonskaya 06*. But all these varieties were season bound or photo-thermo sensitive in nature. Now, in addition to the season bound varieties (as rabi crop) we have already started to grow photo thermo insensitive varieties in our Agricultural Experimental Field as well as at the Agricultural Research Farm of Govt. of West Bengal at different locations in the district of North 24-parganas, West Bengal to find out the adaptability and yield performance in response to various combinations of fertilizer doses. The findings of the experiments will help the sugar industries in future.

S. Barik, S. Chanda, D.K. Dasgupta (BCKV, Kalyani) and D. Konai (Director of Agriculture, Govt. of West Bengal)

Biological Anthropology Unit

Research and other Scientific Activities

Health and disease among populations inhabiting contrasting ecological niches

The project evaluates and documents the health and nutritional problems of the study populations to understand how these populations have worked out strategies for bio-cultural survival in a given eco-niche. The specific objectives of the project are: (i) to examine the effects of ethnicity and lifestyles on health of selected populations inhabiting contrasting eco-niches. The two contrasting eco-zones being studied are: hill/mountain (Sikkim) and coastal (Orissa). The population groups selected for this study are: Rai and Bhutia (in Sikkim) and Shabar (in Orissa). The interim findings of the study reveal significant ethnic differences in demographic (e.g., fertility and mortality), and some health aspects

(e.g., child malnutrition, adult obesity and hypertension) in the Sikkim hills and also lifestyle-related differences in respect of demographic features among the Sabars inhabiting Orissa.

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

Genetics and dermal ridges

Data on quantitative finger dermatoglyphics include 500 pedigrees (2435 individuals) including two generations from five ethnically and geographically different populations of West Bengal. Segregation analysis was applied (MAN-5) on factors extracted from Principal Component Analysis with a view to examine the genetic nature/inheritance pattern and extent of variation in the five populations. Significant major gene effect with two co-dominant alleles was found in all populations strongly supporting the existence of a common nature of dermatoglyphic trait inheritance. The comparative findings of segregation analysis based on factor and individual trait are similar, represent the same mode of inheritance with major gene involvement, which indicates their biological relevance is influenced by the same genetic component.

B. Karmakar

Genomic diversity of Adi tribal cluster of Arunachal Pradesh

Tibeto-Burman speaking population living in north and northeastern parts of India is characterized by a variety of populations of mongoloid ethnic origin. They possibly came from different stocks, at different historical periods and from different directions but the clarity does not exist in respect of the origin, migration, and extent of diversity. Presently such issues are being investigated with the molecular genetic markers. The present project on Adi tribal cluster ingvestigates the extent of genetic diversity among the Adi sub-tribes and its relationship with other neighboring Tibero-Burman speaking tribes inhabiting India and other southeast Asian countries. The project will help understanding the origin and diversity of the mongoloid ethnic contribution to the present day Indian populations.

T.S. Vasulu

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

The aim of the study is investigating the magnitude of secular changes in the measures of body size, body shape, parameters of the adolescent growth spurt, body composition and nutritional status of the school aged, adolescents and adults of the urban Bengali population inhabiting the Kolkata city. Two previous growth surveys performed on the Bengali population about two to four decades ago are considered as the baseline for secular comparison. The study further aims to investigate the role of different household and socioeconomic factors responsible for the secular phenomena in the light of transitional situation of the city.

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

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

We have collected more than 1200 blood samples from 21 groups of Austro-Asiatic and transitional groups. From about 700 blood samples collected in the first quarter of the year 2004, DNA was isolated, quantified and diluted. All these samples along with the previously collected samples were typed for different mtDNA HVS1 and SNP markers. In addition all the males were typed for 12 Y-SNP and 20 Y-STR markers. For the sake of comparison we have also typed some additional Y-SNP and the 20 Y-STR markers in a subset of samples we had collected from Garo and the groups of Khasi.

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

From about 40 populations of Andhra Pradesh we have collected more than 2100 blood samples and DNA has been isolated and quantified. All these samples have been typed for 9 autosomal STR and based on this a manuscript has been developed and communicated. Further, we have sequenced mtDNA HVS I & II regions and typed mtDNA 9 bp and relevant SNPS. We have also typed Y-SNPs and 20 STRs in all the male samples.

Human Genetics Unit

Research and Other Scientific Activities

The Unit has been pursuing research projects, both internally and externally funded. During the year under review, scientists of this unit published 15 papers in various scientific journals. They have also been participating in teaching activities in the Institute and other Institutions. Brief accounts of research activities are provided below:

Genomic studies among ethnic populations of India

The major objective of these studies is to reconstruct human evolution in India. In particular, we have been attempting to reconstruct the processes of peopling and migration from and to India. Last year, we had completed a comprehensive study using mitochondrial DNA, Y-chromosomal and autosomal genetic markers, that provided an in-depth view of the antiquities of various ethnic groups in India, the extent of in- and out-flow of genes, the differential effects of male and female migration, and genetic affinities among diverse ethnic groups of India. This year, we have concentrated on Y-chromosomal markers by adding a large set of markers of greater phylogenetic resolution, since migration to India was primarily male-mediated. We have generated high-resolution Y-chromosomal DNA polymorphisms on about 950 males drawn from various ethnic groups of India, and are in the process of statistically analyzing our data and comparing these with other published data from relevant global populations. We hope to be able to publish a major manuscript within the coming months. These studies have been jointly funded intra-murally and extra-murally by DBT.

P.P. Majumder and colleagues

Genomic studies on Gilbert's syndrome

We have completed a study on Gilbert's syndrome in which patients suffer from high levels of unconjugated hyperbilirubinemia. We have sequenced the UGT1A1 gene and have discovered a new CAT insertion in the promoter of this gene. Additionally, we have discovered many single nucleotide polymorphisms in this gene. In order to study the clinical impact of the CAT insertion, we have carried out a functional assay (by cloning and luciferase reporting in a hepatic cell-line). We have discovered that the CAT insertion decreases the expression of the UGT1A1 gene and, in turn, increases bilirubin levels to clinically adverse levels. This finding has major public-health implications.

P.P. Majumder and Abhijit Chowdhury (IPGMER, Kolkata)

Genomic studies on hepatic disorders resulting from the use of anti-tubercular drugs

Genomic DNA from anti-tuberculosis drug induced (ATD) hepatotoxic pediatric patients has been studied to know the risk of the disease due to polymorphisms present in CYP2E1 and NAT-2 genes. The observation was that CYP2E1 variant genotype and haplotype increased the risk of ATD hepatotoxicity in pediatric patients like adult patients. But, unlike in adult patients, NAT2 polymorphisms did not change the risk of the disease. But a larger sample size is needed to have better understanding of association between the risk of ATD hepatotoxicity and polymorphisms in drug-metabolizing genes.

B. Roy and Abhijit Chowdhury (IPGMER, Kolkata)

Genomic studies on oral cancer

Polymorphisms in DNA repair genes such as XRCC1 and XRCC3 have been studied in genomic DNA of oral precancer (leukoplakia) and cancer patients to know the risk of the diseases due to these DNA sequence variations. Variant haplotypes on XRCC1 increased the risk of leukoplakia and cancer among mixed tobacco users. It was also observed that GSTP1 and XRCC1 independently could not increase the risk of cancer and the presence of two risk genotypes in smokers could increase the risk of cancer. So, it could be assumed that multiple risk genotypes on a locus/two or more loci increase the risk of cancer.

B. Roy

Genomic studies on cervical cancer

Cervical cancer is the foremost cancer burden of Indian women and human papillomavirus (HPV) infection is the major etiologic factor for the disease. 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. We have been able to delineate the involvement of genetic changes in the host related to SNPs in cell cycle regulatory genes, p53 and p21. These two genes act in series in mediating cell-cycle arrest. However, the two risk factors, p53 proline homozygosity and p21 arginine allele, although part of a common causal pathway, appeared to act in a mutually exclusive manner in enhancing disease risk.

S. Sengupta

HPV infection and cervical cancer in the Northeastern States of Manipur & Sikkim

High-risk HPV infection was found to be significantly associated with abnormal cytological lesions in women from Sikkim but not from Manipur. Among the high-risk HPV types, HPV16 was most prevalent in Sikkim, while HPV18 in Manipur. The age-specific prevalence pattern of high risk HPV among normal women revealed that such infection increased to a maximum among those of age 35-39 years, with a subsequent sharp drop thereafter in Sikkim. In Manipur, such prevalence increased with increase in age of the subjects and was the highest at age > 50 years. While life-style/reproductive factors such as, tobacco and oral contraceptive use, low age of consummation of marriage, low age of first childbirth and high parity were significant determinants of high risk HPV infection in this population, no such factors appeared to influence the infection in Sikkim. The findings point towards the need for the analyses of genetic factors, which might play a differential role in HPV infection and disease manifestation in the two populations.

S. Sengupta and S. Mukhopadhyay

Statistical Genomics

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

developing an age-adjusted Sib Transmission Disequilibrium Test where a Cox Proportional Hazard Model is used to estimate the probability of an individual, currently unaffected, to manifest the disease in the future and hence, obtain an "effective" number of affected and unaffected sibs in the family;

extending our earlier work on non-parametric regression for QTL mapping from sib-pairs to sibships using a contrast and mean function;

modifying the existing variance components, Haseman-Elston and logistic methods for mapping autosomal QTLS to X-linked QTLs;

developing a multivariate phenotype approach to dissect an end-point binary trait based on a linear regression strategy using identity-by-descent scores as the response variable and phenotypic observations as the explanatory variables; and
identifying polymorphic motifs from DNA sequences using probabilistic search algorithms, in a single data set or in case-control data sets.

Analyses were performed on:

the Simulated dataset of Genetic Analysis Workshop 14 to study Konfedred Personality Disorder and

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

P.P. Majumder and S. Ghosh

Social Sciences Division

Economic Research Unit

Research and other Scientific Activities

Agricultural Economics

In a continued research interest in the field of efficiency and productivity measurement, attempts have been made to develop some analytical tools to examine labor-use efficiency and tenurial inefficiency in the agrarian economy of India.

M. Chattopadhyay

An attempt has been made to predict rice yield with the help of various meteorological parameters using a dummy explanatory variable approach in sub-humid eastern plateau of India. Since only ten years' data were available, a unified approach has been taken to include all the six varieties for regressing yield on the explanatory variables using 'dummy variables'. This increases the degrees of freedom very much and the number of explanatory variables can be increased sufficiently.

M. Pal

Applied Econometrics

The issue of food price comparisons, both spatially within a country and between countries, is fundamental to welfare analysis, especially in the context of development. In multilateral consumer price level comparisons, mismatch of the list of items consumed in individual countries poses a major problem. However, given sets of household level nutrient prices and corresponding nutrient intakes, a set of multilateral nutrient price index numbers may be worked out to compare nutrient price levels across population groups. Such a set of index numbers would facilitate the task of comparison of the overall consumer price levels across countries/regions. A regression analysis-based procedure has been proposed for estimation of household-level unit values of major nutrients, namely, carbohydrate, protein and fat. The proposed procedure has been applied to the Indian household level data for the year 1999-2000 provided by the 55th round Consumer Expenditure Survey of the National Sample Survey Organisation, Govt. of India. The estimated nutrient prices have been used to define poverty line. Using this and other alternative poverty lines, the incidence of poverty corresponding to alternative poverty lines have been compared separately for the rural and urban sectors of the major Indian States.

A. Majumder and D. Coondoo

A model of buying behavior of Indian consumers has been developed using the 'Dirichlet model', which describes, for a stationary and non-segmented market, the purchase behaviour of frequently bought branded consumer products. Validity of the model, which assumes mixtures of distributions at different levels, namely, negative binomial, multinomial, multivariate beta has been examined for the Indian consumers.

Pulakesh Maiti

Weighing mechanism for deriving an index of infrastructure performance of the states of India is being formulated.

In another study, new methods of explaining divergence of income across Indian states are being proposed.

B. Ghosh

Applied Financial Economics

In the area of volatility measurement, a descriptive decomposition of the observed volatility of a variable into three components has been proposed. These components have been named the *Strength*, *Duration* and *Persistence* of volatility. This decomposition is interesting and useful because it is unique and is such that measurement and analysis of these components will facilitate a better understanding of the nature of volatility of a variable, comparison of the patterns of volatility of two or more variables and precision of volatility. The proposed methodology is illustrated by applying it to the time series of daily observations on three variables, viz., stock return, inter-bank call money rate and FII inflow.

D. Coondoo

In this study, an Arbitrage Pricing Model (APM) is built on returns from shares in National Stock Exchange (NSE). The APM of returns from shares has four explanatory variables- Market Trend (Market Index), Sector Specific trend in the Market (IT Index), Size of the company (Daily Turnover) and Location factor of the company (Index of Industrial Production). In comparing the distribution of the residuals, it has been observed that the exponential distribution performs better than lognormal and normal distributions. Univariate kernel smoothing method is also undertaken for univariate model based on returns dependent on IT Index. It has also been observed that Exponential distribution performs better than Kernel smoothing and Normal distributions in Univariate model.
Another objective of this study is to find out a nonparametric regression model for the APM.

D. Mukherjee

Child labour

Theoretical analysis of the child labour market in the less developed countries has become an important area of research in development economics. Work on the determination of wage rate of child labour and on identifying the factors affecting the supply of and demand for child labour is being carried out. The implications of debatable policies like banning child labour or imposing trade sanctions on child labour intensive products are being studied.

M. R. Gupta

In the topic of parental altruism, ability and education, this study explores the relationship between ability and investment in human capital, when investment in human capital consists mainly of parents' investment in their children's education. It is shown that in steady state abler individuals tend to get skilled, while less able individuals tend to remain unskilled. However, there may exist situations where the relationship between abilty and skill-formation in steady state may be a bit more complex.

C. Ghosh

Cooperative Games

Axiomatic characterizations of some indicators of individual voting power and a global sensitivity index have been carried out. Some analytical properties of these indicators have also been examined.

S. R. Chakravarty

A general sufficient class of coalitional form games with transferable utility, for which the Shapley value coincides with prenucleolus, is identified. The result is applied to simple games and to generalized queueing games.

M. Mitra

Demographic Studies, Women Studies

This study relates to simple search and bargaining model of marriage. In the young age, each person starts with an endowment of financial resources and an inherited cultural orientation. They acquire a

marketable human capital and optimally modify their cultural orientation using this endowment. In the second period of their lives, a search for the right spouse and then bargaining for the household orientation, with the chosen spouse, ensues. The resulting pattern of marriage is shown to evolve an unequal distribution of population across the cultural spectrum with considerable concentration in the middle or moderate region. The model is illustrated using a preference for fertility and the resultant distribution of population.

D. Mukherjee

In the area of women studies, attention is now being paid to empowering women so that they can play more effective role towards overall development of the society. Among various means of empowerment, economic empowerment is most important as it gives freedom to choose among various alternatives for achieving a state of well-being and power to take a decision. This study concentrates on the inequality faced by women in the labour market as a most important indicator of empowerment using data on West Bengal, Bihar, Jharkhand and Orissa. It is found that the degree of sexual equality is least in West Bengal relative to all India situation. Only in Orissa this degree of sexual equality is close to the desired level.

C. Sharma Biswas

Women's integral participation in all spheres of society, economic as well as non-economic, is now well known. Their active involvement in the process of decision making in every aspect including political process is all the more crucial. While most studies on women's participation in politics, attempted so far, were basically to analyse the role that women played in Indian Parliament, this study attempts to analyse the background and role of women in Legislative Assembly of West Bengal from 1957 to 1996.

S. Das and C. Sharma Biswas

Measures of Gender Inequality, so far proposed in the literature, are reviewed. Some measures that can be derived from the existing measures of inequality by decomposing into within and between population groups, the groups being male and female population, are proposed.

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

In another study, the different measures of gender and racial segregation are reviewed. Though segregation is usually measured between two groups of people like men and women, Negroes and non-Negroes etc., one may visualize it in a multi-group set up also. The work examines how one can generalize these measures to more than two groups. Spatial racial segregation opens up new concepts of segregation, namely, concentration or isolation and interaction or exposure. Measures are proposed for each of these concepts.

The study on estimation of the neonatal, infant and child mortality rates in North 24 Parganas, West Bengal, finds that (i) the location, accessibility and type of health facility available in rural areas are important factors that can substantially reduce the infant and child mortality rates, (ii) lack of education and health awareness related to common illness, cleanliness, dietary habits etc. are some of the associated factors of high infant and child mortality rates in the rural parts and (iii) proper and regular immunization and intake of iron and folic acid tablets reduce mortality rates substantially.

A study on a few selected socio-biological and demographic determinants of birth weight was conducted at a hospital in Sagar town, Madhya Pradesh. Records of 2680 single live births over a period of one year (1st January to 31st December 2000) were analysed. It was found that male infants were 124 gm heavier than female infants. Tabular representation of data showed that maternal age, education, ethnicity, father's income and occupation, infant's sex and parity have strong association with birth weight of infants. Regression analysis gave a comprehensive picture of such associations and confirmed the above findings and showed that the socio-economic and biological variables

considered in the analysis have significant effect on birth weight. Malnutrition among children is prevalent in almost all the states in India. This study assesses the extent and causes of malnutrition in two eastern Indian states with similar climates, namely, West Bengal and Assam, using data from the National Family Health Survey 1998-99 (NFHS-2). The three indices of malnutrition taken for analysis are weight-for-height (WHZ), height-for-age (HAZ) and weight-for-age (WAZ). These are assumed to depend on birth order, preceding birth interval, parent's educational status, working status of the mother, mother's age at delivery of the children, source of drinking water, toilet facilities and standard of living of the household. Logistic regression was carried out separately for each of the three indices on the explanatory variables for both states. It was found that not all variables are equally important in determining whether a baby is underweight, or suffering from acute or chronic malnutrition. Also, the importance of variables is not the same in the two states. It was observed that the coefficients associated with the variables in determining weight-for-height are not significant compared with those for weight-for-age and height-for-age.

M. Pal

Endogenous Growth

A theoretical model of endogenous growth to study the impact of free trade on a small open economy, with special emphasis on public infrastructure development is developed.

Work on the book 'Growth Theory: Solow and his Modern Exponents' has been completed. It gives a comprehensive view of the subject by referring back to a simple theoretical scaffolding involving the laws of demand and supply as applied to a growing economy.

D. Dasgupta

Environment and Resource Economics

Control of pollution, preservation of natural environment and optimal use of natural resources are major concerns of both the developed and developing countries. The technologies in this regard are available with the developed countries. But the suitability and adaptability of these technologies in the developing countries are very much constrained by various socio-economic, technological barriers as well as non-availability of certain resources, particularly exhaustible resources. Research is being carried out on suitable policies in the area of pollution abatement, waste management, use of alternative resources, specifically in energy sector, subject to these constraints.

Snigdha Chakrabarti

In a study, the pattern of relationship between the cross-country distribution of income and CO_2 emission and temporal shifts in such a relationship have been explored. In this country-group level analysis based on a cross country panel data set, it has also been examined how the mean level of per capita CO_2 emission and its distributional inequality may be related to the corresponding mean income level and the distributional inequality of income. The technique of Lorenz and specific concentration curve analysis have been used as the basic analytical tool for this analysis. Based on the results obtained, it has been argued that along with the mean income level a measure of relative distributional inequality of income should be used as an explanatory variable in the *Environmental Kuznets Curve* (*EKC*) relationship. In the empirical exercise, Johansen's cointegration analysis technique has been used to explore existence of statistically significant cointegrating vector(s) relating mean level of emission and *Specific Concentration Ratio* (*SCR*) of emission to mean income level and *Lorenz Ratio* (*LR*) of income. The empirical results confirm that the pattern of cross-country income distribution has indeed a significant effect on the mean level of emission for all the country-groups considered.

D. Coondoo

A study on the extent of households' awareness about different types of environmental hazards was carried out. This was based on a sample survey of households in the urban areas of Howrah district in West Bengal.

Pradip Maiti

As an extension of an earlier study on East Calcutta Wetlands, some other areas like zoology, botany are being explored to capture non-economic environmental costs and benefits of the wetland.

K. Chattopadhyay

Human Development and Social Economic Indicators

An axiomatic characterization of a family of Human Poverty Indices using an arbitrary number of dimensions of life has been developed. This has important policy applications for identifying the attributes that are more susceptible to human poverty. An empirical illustration has been provided using cross country data for basic dimensions of life considered by UNDP and several anthropometric indicators.

S.R. Chakravarty and A. Majumder

During recent decades the concept of human well-being has shifted from economic to economic and non economic aspects of life. This work tries to assess the condition of the poor, in terms of some selected economic and non-economic indicators of human lives, in the North East region, which is geographically quite different from rest of the country. The work also deals with the problem of poverty estimation in the region. Data, provided by the National Sample Survey Organization (NSSO) for the latest large sample round conducted in 1999-2000 have been used for the study.

S. Das

Human history observed significant improvements in life expectancy over the second half of the 20th century. A study has been going on to explore the causes and the consequences of such development.

In another study, the convergence of countries in socio-economic aspects has been examined. It is expected that with emphasis on globalization, countries should converge in the socio-economic aspects. But application of standard tests for convergence/divergence shows divergence for the world in all aspects considered.

A study was conducted on 'Quality of Life in Asia-Pacific Countries: 1975 – 2000' to find the improvements and growth rates of fifteen Asia-Pacific countries in different socio-economic and environmental aspects of life. The study also estimated elasticities of human well-being in health, education, and environment as well as overall human well-being with respect to economic well-being.

A new composite index has been formed for fifteen Asia-Pacific Countries for 1975 – 2000. The index comprises indicators related to economic, social and environmental aspects of life. Growth rates of these economies over the period have been compared with the growth rates obtained from Per capita gross domestic product, Per capita real gross domestic product, Human Development Index and Physical Quality of Life Index.

K. Mazumdar

The study on Impact of Globalization on Human Development in India reviews the most recent literatures on pre- and post-globalization comparison of human development aspects among different states of India and tries to reexamine the possible impact of globalization on Indian States. Major discussions are centered on Poverty, Inequality and Per Capita Consumption of States. The other aspects of development like Literacy, Infant Mortality Rates (IMR), Gender Inequality, are also considered. It seems that economic growth reduces poverty but fails to reduce inequality whereas literacy has direct influence on the other aspects of development like IMR, Gender Inequality, etc.

M. Pal

Industrial Economics

Various hypotheses relating to the the following are being investigated with the help of SSI data collected from ISI survey by B. Ghosh and C. Neogi from the districts of West Bengal: (a) wage differentials between skilled and unskilled workers, (b) productivity differentials between relatively

smaller and larger firms, and (c) employment intensity between smaller and larger firms, under globalization.

In another study, productivity and competitiveness in Indian and Japanese industries are being studied.

B. Ghosh and C. Neogi

To measure the efficiency and productivity of Indian industry, Data Envelopment Analysis (DEA) was applied to firm level data. A special feature of the model is that it gives the input specific efficiency of each firm of an industry. Also, some analysis was done to identify the source of inefficiency of firms.

C. Neogi

Applying the stochastic frontier production function approach to the unit level data obtained from C.S.O.'s Annual Survey of Industries, an attempt has been made to estimate the variation of technical efficiency across different firms in the Textile industry of India. Attempt has also been made to explain such variation in terms of firm specific variables.

Pradip Maiti

Industrial Organization

Theoretical models are being developed to analyze the impact of IPR protection on the innovation, technology transfer from the innovator to other firms and the welfare implications. This also incorporates the different modes of technology transfer such as FDI, licensing and exports from the developed countries to the developing countries. Under the current WTO regime, the trade-off between product versus process patent regime is also the focus of some studies. The models also highlight the issues related to competition policies for an economy under the liberalized economic regime.

T. Kabiraj and U. B. Sinha

Infrastructure and Economic Development Linkage

The relationships between (a) infrastructure facilities and economic development in general across Indian states, (b) states' own efforts at developing new infrastructure facilities and success in poverty removal, and (c) education, health and gender of the poor on the one hand, and growing withdrawal of the government from basic amenities, on the other, are being investigated.

In another study the role of transaction cost in Asian as well as BIMST-EC economic cooperation are being investigated.

The India Infrastructure Database 2005 (Volumes I and II), which comprises 16 chapters, and presents about 1000 tables, has been organized. It also includes cross-country information of all possible infrastructure facilities. Attempt is being made to convert these data into electronic format.

B. Ghosh

Input Output Models

In a study on structure of production, inflationary process and income distribution, a price version of the input output model has been formulated such that any discrepancy between final demand growth and output growth can be translated into price rise or fall. The impact of the above on income distribution has also been accommodated by endogenising household sectors.

A. K. Sengupta

International Trade and Economic Development

In the area of trade and wage inequality, the empirical observations point to the fact that wage inequality has been rising all over the globe. If this were to be initiated by international trade then the

standard Heckscher-Ohlin (H-O) model fails to give a theoretical account of such symmetrically rising wage inequality. The current literature has therefore chosen to construct variants of H-O model to establish formally how wage gaps can symmetrically increase in both the trading countries. But in so doing these models have abandoned the factor price equalization (FPE) framework. Models, wherein it would be possible to account for symmetrically rising wage premia in an FPE framework, are being developed.

Bratisankar Chakrabarty

Market Structure and Competition

The implications of different licensing contracts from the viewpoints of the consumers and producers separately and as a whole are discussed. The study also discusses which licensing contract should be optimal, how to implement such a policy and the importance of the prevailing market structure.

The other studies discuss (i) how R&D affects market demand for a product and what R&D organization gives larger incentives for innovation, (ii) how the possible synergy and learning may result in changing the industrial structure by means of formation and break down of joint ventures.

In another study it is shown that the firms across borders may sometimes form joint ventures not for immediate gain but to make possible future gain from superior technologies that may be available in the future.

T. Kabiraj

Mechanism Design

In the topic 'Mechanism design and queueing and sequencing problems', with different cost structures, this study characterizes the class of cost structures for which one can design mechanisms that leads to (a) aggregate cost minimization, (b) extraction of private information and (b) budget balancedness.

In the topic 'Mechanism design and allocation problems', this study characterizes, subject to mild technical assumptions, heterogenous and homogenous object allocation problems where an efficient rule can be implemented in dominant strategies with balanced transfers. It is shown that the class of such problems is non-trivial and that the associated domain is one-dimensional.

In the topic 'Mechanism design and regulation problems', this study derives the mechanism that can be used to regulate a monopolist when the planner has limited transfers and the marginal cost of the monopolist is private information.

The mechanism design problem of the regulator in a market where the incumbent firm owns an essential facility and the regulator wants to introduce competition in this market is also addressed.

M. Mitra

North East Economy

The major part of Indian population still depends on agriculture. It is also observed that though Indian population grew by 2.3 times over the period 1951 to 1991, foodgrain production in this period grew by 36 times. But surplus foodgrain production does not ensure food security to the population, as food security depends both on efficient food distribution system and effective demand. This study concentrates on the potential and performance of agriculture, food distribution system and people's purchasing power in the North East (NE) Region. It is found that on the one hand, due to porous nature of the NE states and adverse communication, public distribution system falls. On the other hand, declining trend in employment with increasing per worker dependency leads to reducing purchasing power of individual.

C. Sharma Biswas

An estimate of the existing coal reserve situation in the North-Eastern region of India has been made. The prospects and constraints therein are identified as well.

In another study it is argued that there should be a comprehensive policy of defence and development for border states. Infiltration, cross-border terrorism can successfully be dealt only with the fullest co-operation and utmost vigilance of the people. Therefore, development of livelihood of people living in international areas has to be given equal emphasis with defence if we really desire to curb undesirable cross-border activities.

Subhendu Chakraberti

Political Economy

It is now a well-accepted fact that markets, though they can bring about efficiency in a wide range of circumstances, cannot solve all the problems an economy can possibly face. This phenomenon of market failure is particularly pronounced in less developed countries where a large section of the population is disadvantaged and is unable to participate in the market. In situations of market failure, it is the government who has to perform an important role. But like market failures, there are possibilities of government failure as well. The institution called democracy can then bring about a change in the government. The present research is broadly concerned with the question whether democracy is playing this desired role in less developed countries. On the one hand, it tries to build up theoretical models of political economy which are applicable particularly to less developed countries. On the other hand, it looks at empirical support for the theory by considering the political economy of the state of West Bengal.

A. Sarkar, S. Mitra and C. Neogi

Time Series, Econometric and Statistical Methods

Fama's efficient market hypothesis (EMH) envisages that the market is not predictable, i.e., predictability is an evidence of departure from EMH. Thus, studying predictability of a financial asset like India's stock market index is important. We have obtained best predictive model at the level of stationary data (called returns data in the context of stock market) using predictive criteria like in sample and out-of-sample forecast performance, Theil's U, MSE-F and ENC-NEW. Further, since these data sets viz., BSESENSEX, BSE-100, NIFTY & DOLLEX are highly non-linear in nature, due consideration in the form of ARCH/GARCH in conditional variance as well as nonlinearity in the conditional mean specification have also been given while carrying out the data analysis.

Nonlinear time series modelling approach has been extensively used in predicting exchange rate variable. In this approach the class of threshold autoregressive (TAR) models is well-known. A particular member of this class viz., self exciting TAR (SETAR) has found vide application because the decision rule used for the purpose of deciding in the threshold is simple yet meaningful enough. There is also the class of Market switching regimes model. For foreign exchange rate market, the role of intervention by the Central Bank (RBI in India) is very important to explain structural changes. Studies have been /are being carried out to understand the role of RBI in India in stabilizing the foreign exchange market.

Volatility is one of the most important characteristics of financial data like stock market index, foreign exchange rate, etc. However, the observed volatility may be of more than one kind across observations although no explicit knowledge for each observation is likely to be known in the data. A proper analysis in such situations calls for application of mixture model approach. Till today, this approach has been confined to the mean level analysis only. Work is being carried out to extend this in the context of conditional heteroscedasticity as well.

N. Sarkar

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

Pulakesh Maiti

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

Pulakesh Maiti

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

Pulakesh Maiti

In a Unified Approach to the Frontier Production Function Models with Correlated Non-Normal Error Components, the Stochastic Frontier Production Function (SFPF) Models with error components, termed as technical inefficiency, error and noise variable in a cross section framework is reviewed. It tries to unify all such models incorporating (i) truncation or non-normality of the technical inefficiency error term and (ii) correlation between the two error components. Allocative inefficiency error terms are also introduced and are assumed to be correlated among themselves.

The correlation between Technical and Allocative Inefficiency errors in Stochastic Frontier Production Functions is examined. A model of Stochastic Frontier Production Function (SFPF) is developed introducing both technical and allocative inefficiencies under the assumption that technical inefficiency error and the allocative inefficiency errors are correlated. The marginal distribution of the technical inefficiency error is taken as truncated normal instead of half-normal, the point of truncation being at zero. The allocative inefficiency errors are also correlated among themselves. Estimation of parameters including those of technical and allocative inefficiencies are discussed and illustrated through an Indian data on agricultural farms.

M. Pal

Extreme Observations (EOs) play a significant role in the estimation of Frontier Production Functions (FPFs). The estimation of FPFs is known to be very much sensitive to the presence of EOs. This Work reviews how the different models of single equation FPFs and the estimation procedures were developed in order to tackle the problem of EOs starting from the model proposed by Farrell (1957). It then proposes a model of FPF with Errors-in-Variables (EIVs) and shows that the model may be effective even when the EIVs are negligible.

M. Pal, C. Neogi and B. Ghosh

Welfare Indicators and Measurement of Poverty

The class of absolute income polarization indices whose orderings of alternative income distributions agree with the rankings generated by nonintersecting absolute polarization curves has been identified. Different absolute inequality indices, based on social welfare functions have been employed to construct alternative absolute polarization indices. An empirical illustration has been provided using data on the Indian states.

S. R. Chakravarty and A. Majumder

An attempt to extend multidimensional poverty measurement to a fuzzy environment using axiomatic approach has been made.

S. R. Chakravarty

An axiomatic development of a family of poverty measures that becomes useful in empirical and policy work has been presented without a population replication axiom.

S. R. Chakravarty and D. Mukherjee

There is a glaring paradox in all commonly used measures of poverty. The death of a poor person, because of poverty, reduces poverty according to these measures. This surely violates our basic intuition of how poverty measures should behave. It cannot be right in concept that differentially higher mortality among the poor serves to reduce poverty. This study begins the task of developing poverty

measures that are not perversely mortality sensitive. A family of measures is proposed that is an intuitive modification of standard poverty measures to take into account the fact that the rich live longer than the poor.

D. Mukherjee

The Discussion Papers' posted at http://www.isical.ac.in/~eru/ provide an overall view of the Unit's current research activities.

During this period ERU has undertaken four plan projects, three of which are workshops. Two of the plan projects are related to the North-Eastern region of India.

The workshop on 'Quantitative Analysis of North East Indian Economy' was organised in collaboration with the Department of Economics, Dibrugarh University during 13–18 December 2004. The purpose of this project was to have an exchange of ideas between academicians of the Indian Statistical Institute and the North-East Indian Universities regarding the economic problems of North-East India and application of related quantitative techniques to analyze them. Thirty two workshop participants were selected from Research Scholars/Faculty members in Economics of under-graduate colleges and universities of North-East India. Of them, twenty six turned up from colleges/universities of Tinsukia, Shivsagar, Jorhat, Chabua, Golaghat, Lakhimpur, Nagaland, Manjuli, Manipur, Nagaon, Silapathar and Margherita. The rest were from local colleges in Dibrugarh. Participants were offered one set of compusory topics (Microeconomics, Macroeconomics, Basic Econometrics and Survey Methods) and either of the two sets of optional topics (Optional – 1: Development Economics, Advanced Microeconomics, Environmental Economics; Optional – 2: Advanced Econometrics, Time Series). Resource persons consisted of members of E.R.U., Dibrugarh University and NEHU. The workshop turned out to be a success and the responses from the participants were overwhelming. The workshop was organized by Amita Majumder, Dipankor Coondoo, Sandip Mitra and Subhendu Chakrabarty.

The Economic reasearch Unit organized the Fourth Annual Conference on Models and Methods in Economics during 8 – 10 December 2004. Prof. Anjan Mukherjee, Prof. Arunava Sen and Prof. Dilip Mookherjee gave invited talks and there were 21 contributed papers. The conference was well attended and speakers were from all over the country as well as from abroad (18 outstation speakers). A wide range of topics was discussed. The conference was organized by Manipushpak Mitra and Uday Bhanu Sinha.

The unit also organized a Two-Day Workshop on Industrial Organization and International Trade during 11–12 February 2005. Twelve papers were presented. There has been a very fruitful interaction among the researchers and faculty members of the unit. The workshop was organized by Brati Sankar Chakrabarty and Abhirup Sarkar.

The plan project 'Study on some Health Economic Issues in the North East' started in April 2003. Data collection, computerization, partial tabulation and analysis had been done during 2003 – 04. The project has been completed in March 2005. It has provided a micro-level study on the specific problems of tribal heath and sanitation in North-East India. In particular, it has examined the private health care system and the coverage of health insurance scheme for the tribal group, the Khasi.

S. Mitra, M. Pal and B. Bhattacharya

The other plan project 'Political Economy of Well-being of West Bengal' which is an ongoing project started in April 2004. The aim of this project is to study the interrelationship between economic well-being of individuals and political process of a democratic country. It searches for answers to the following questions. To what extent do individuals respond to the changes in the economic condition through their voting behavior? Do we expect lower vote shares of the ruling party in a region where economic performance has been relatively poor? Does voting history matter while allocating funds for economic development? A sizeable amount of data has already been collected and analyzed.

A. Sarkar and S. Mitra

Finally, as in other years, this year also the scientific workers of ERU have been involved in teaching various courses in economics and econometrics for the B. Stat. (Hons.), M.Stat., I.S.E.C. (regular and specialization) and MS(QE) programmes. Ten research fellows are currently working for their Ph.D. under supervision of members of the faculty of ERU.

Economic Analysis Unit

Research and other Scientific Activities

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

N.S.S. Narayana

Linguistic Research Unit

During the period under consideration, the Linguistic Research Unit continued its programme of research in the areas of Quantitative Linguistics, Clinical Linguistics, Sociolinguistics and Neurolinguistics.

Research and other Scientific Activities :

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

Methods in Quantitative Linguistics : (a) Research design in applied linguistics, (b) Text as a linguistic paradigm, (c) Language Modeling.

Sociolinguistics : (a) Study of Language attitudes, (b) Language planning in a plural society, (c) Language and Mass Media.

Clinical Linguistics : Habilitation of hearing impaired children.

Neurolinguistics : (a) Neurolinguistic perspectives in studying language disorders, (b) Development of Test Batteries.

Quantification And Non-Quantification: Searching For Convergence Methods in quantitative linguistics.

The aim of this study is to develop research methods with particular reference to qualitative and quantitative research in applied linguistics. Historical, descriptive, developmental, co relational, experimental, case-study, and other types of research models will be accounted for and critiqued in the context of applied linguistic research. The focus is on research design in the various types of research mentioned above.

Text as a linguistic paradigm

A text has so many facets that its examination nowadays makes up a vast scientific area in which researchers from several disciplines are engaged. There is a wealth of mathematical methods with the aid of which particular problems could be solved, or which could trigger the construction of partial theories. Many texts from Indian languages have been analysed and efforts are on to develop concordance packages in Indian languages.

Language modeling

Human language technology systems have typically focused on the "factual" aspect of content analysis. Other aspects, including pragmatics, point of view, and style, have received much less attention. However, to achieve an adequate understanding of a text, these aspects need to be explored and studied in depth. The two languages to be taken up in the first phase are Bangla and English with the possibility of taking up Tamil in the next phase.

Study of Language attitudes

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

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

Plan Project Title: Language Identification, Classification And Analysis In Children With Neurolinguistic, Speech And Hearing Disorders

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

Data collection has been carried out extensively by visiting various institutions dealing with the habilitation of the children with speech disorders. The developmental status of various speech sounds for language development has been studied as a foundation for understanding delayed milestones in language and related disorders, including the impact of hearing loss, psycho-social variables affecting language acquisition, disorders related to, congenital and acquired cognitive disabilities, etc. Different methodologies have been taken into consideration in order to develop an integrated habilitation program in order to bring the individuals affected with such neuro-linguistic problems into the main stream of education. Language programming in educational setting has been made an integral part of the research programme.

Neurolinguistic perspectives in studying language disorders

Work was carried out on Right Hemisphere Damage (RHD) patients in the Indian context. It is even more important than usual to focus on establishing rapport and building trust during initial contact with right hemisphere involved patients. Since RHD patients are frequently unaware of their cognitive and communicative impairments, and are not usually having any trouble finding words, using grammar, or articulating, they may be reluctant to participate in speech therapy.

Development of Test Batteries

A standardized test has been developed for use with RHD patients. Other tests like the Mini Inventory of Right Brain Injury by Pimental and Kingsbury (1989) are being adapted for the Indian situation. Among other things, this battery examines body image, visual scanning, reading, writing, visuomotor

skills and speech intonation. It is a very thorough test. The other test being incorporated is The Right Hemisphere Language Battery (Brian, 1989) tests mainly for extralinguistic problems, evaluating comprehension of metaphors and inferred meanings, appreciation of humor, and the production of emphatic stress as well as other communication abilities, such as discourse analysis.

A. Choudhry, M. Indu, T. Sengupta, S. Ganguly and S. Dattamajumdar have all been actively involved in all the research programmes of the Unit

Planning Unit

Research and other scientific activities

Members of the Planning Unit carried on a wide range of research activities. Some of the areas in which research was undertaken are listed below :

Impact evaluation of primary school education in India.

Water filtration Methods in Gurgaon city.

Vulnerability estimates for Indonesia.

Credit Markets, Loan Contracts and Household Poverty: A Study of Self Help Groups in the State of Jharkhand.

Measuring Deviations from Optimality in Allocations of Public Amenities across Villages in India.

Birth, Gender and Wealth as Determinants of Child Labour: An Empirical Analysis.

An Estimate of Extent of Sub-Standard Drug Sales in Delhi and Their Effects on Public Health.

Mapping Water Demand.

Regional Economic Growth in India: Political-Economy Approach to understanding Divergence and Thresholds.

Labour Productivity in the Indian Steel Industry: A Study of the Blast Furnaces and Rail Mill Department of the SAIL plant in Bhilai.

Theoretical and empirical analysis of the difference in performance levels of private and cooperative plants in the Indian sugar industry.

Theoretical and empirical work on the link between poverty, local governance and deforestation in Uttar Pradesh and Himachal Pradesh.

Growth and Distribution in an open economy framework.

Some specific topics are :
Long term economic effects of HIV/AIDS in India.
Importance of daily status of employment to understand rural labour markets in India.

A. Mukhopadhyay

Characterizing domains over which it is possible to achieve truthtelling in dominant strategies, efficiency and balanced transfers in heterogenous and homogenous multiple-good models.
A new characterization of incentive compatible multi-unit auction models.

A. Sen

Food policy risk and uncertainty issues in agriculture.
Economics of biotechnology regulation, commodity futures markets and the impact of the non-farm sector on poverty.

B. Ramaswami

Extention of the literature on growth and distribution to an open economy framework.
Impact of trade policy on growth.

C. Ghate

Patents and R & D: The tournament effect.
Group-lending: Sequential financing, lender monitoring and joint liability.
Bertrand – Edgeworth duopoly with linear costs: A tale of two paradoxes.

P. Roy Chowdhury

Revision and reestimation of a model of child labour that assumed that a child either went to school or worked (including unpaid domestic work) using NSS data, that was discarded as a large number of children were involed in neither.

S. Das

Income and wealth distribution–namely how trade policy affects inter-and intra-country distribution of wealth and income and how distributional policies afftect economic growth.
Study of the economics of terrorism.

S.P. Das

Population Studies Unit

Research and other Scientific Activities

Featuring Nuptiality of A Few North Eastern States of India

While embarking on the study of population change, there is a need to look into the relatively neglected but important component of nuptiality besides the three other components of fertility, mortality and migration. It is the task of the demographers to investigate the data available for estimating the parametric values (a_0, k and c) and the first marriage frequencies. This type of investigation has not been done till now in respect of some North Eastern states of India but is important and can help in formulating policies for reducing the population growth.

A. K. Saha

Feminisation of Nepali Migration to India

Feminisation of Nepali migration to India is contributed by illegal female migration along the path of open border and trafficking. The contributing factors to trafficking involve deep rooted process of gender discrimination, lack of female education, ignorance of rural folk, poverty, unemployment, lack of economic opportunities, globalisation of the economy, feminisation of poverty and migration and woman's lack of empowerment. A strong social movement, public awareness, a fight against exploitation, injustice and drive against misuse of Indo-Nepal open border may be the solution

P. Datta

Effects of Undocumented Migration from Bangladesh to West Bengal : A Perception Study

Perceptions of respondents are that undocumented migrants from Bangladesh have contributed to increase in working age males and females, child mortality and adult mortality in West Bengal. The reasons of faster population growth due to this influx can be attributed to (a) illiteracy of the migrants, (b) migration by family, (c) unawareness about family planning, (d) lack of easy access to Family Planning method.

Regarding policy issues, respondents argue that the whole issue of illegal migrants should be judged with human face since they are forced and uprooted from their residence by some political, religious, social and economic forces prevailing in the center of origin.

P. Datta, S. Sadhu, B.N. Bhattacharya and P.K. Majumdar

Migration to Assam

The study highlights internal and international migration to Assam. Out of the total population of Assam, 98.48% are Indian born and 1.51 percent are foriegn born. Most of the international migrants (98%) are Asian born. Majority of them are from Bangladesh followed by Nepal and Pakistan. The region is witnessing regular and accelerated phase of economic migration. It is observed that even after legitimizing the pre-1971 migration, about 18% of the population in Assam are illegal migrants. It is true that some political parties in West Bengal and Assam have nurtured the illegal migrants into potent vote bank. Even after passing of long years since the signing of the Assam Accord, the voter list of Assam could not be finalised and only a limited number of foreigners could be identified and deported from the state.

P. Datta

Illegal Bangladeshi Migration to West Bengal

The study highlights the impact of construction of Farakka Barrage, Enemy property act, and illegal migration determination by tribunal act on illegal Bangladeshi migration to West Bengal. Construction of Farakka Barrage did cause environmental destruction in Bangladesh and adversely affected sources of livelihood in Bangladesh and was responsible for illegal Bangladeshi migration. Enemy / Vested Property Act was an effective tool for the extermination of Hindu minorities and one of the dominating forces for illegal migration from Bangladesh to West Bengal. The IMDT act was found to be impractical as many feel that this Act gave a long rope to the migrants to stay in India since it was a time consuming process to determine illegal migrants.

P. Datta, S. Sadhu, B.N. Bhattacharya and P.K. Majumdar

Impact of Demographic and Socio-Eco-Political Factors in Formulating Population Policies around the World

This paper explores the relative importance of factors which affect the formulation of population policy around the world through application of several statistical techniques in analysing data of 179 countries covering years 1976, 1986 and 1996. Change in relative importance of factors affecting formulation of population policies will also be explored.

P.K. Majumdar and B.K. Mukhopadhyay

Possible Determinants of Indian Population Growth in the Recent Decades

The study attempts to analyse the problem of unabated growth of Indian population from an unconventional angle by appropriate statistical modeling. It makes use of all available statewise data on India in the period 1971 to 2001. It shows how various demographic, socio-economic, cultural and spatial factors may be influencing the growth rate. The influencing factors, however, change over the decades along with their relative importance. The paper ends with a question on the synergy among all factors that are associated with various programme efforts for stabilizing population growth.

P. Pathak

Temporal Change in the Contrast Between Female and Male Labour Forces and Workforces in Eastern India

The study brings to light through use of different demographic and spatial indicators how the female labour force and the female workforce are discriminated against in comparison to their male counterparts. It also analyses the spatial and the temporal variation in the discrimination and determines precisely the relative positions of the three eastern States, namely, West Bengal, Bihar and Orissa during 1971 to 1991.

P. Pathak

Pattern of Household Financing of Expenses on Reproductive Health Care for Women in Different Economic Categories in Kolkata Slum

The paper presents the findings of an ISI-sponsored study on 1500 households, selected by inverse sampling from five slums in the Kolkata metropolitan area. It shows the variation in seeking reproductive health care and the variation in the expenses incurred under different service/material heads while availing different types of reproductive health care for women in different economic slabs. The slabs are defined based on per capita monthly consumption expenses. It identifies the most vulnerable segment of women who need special financial and public health service assistance for attaining good reproductive health status without falling in any kind of debt trap.

P. Pathak

Factors That Trouble Assam and Solution Possibilities

The paper attempts at explaining various historical, socio-economic, political, cultural, demographic, spatial and environmental factors that contributed to the present unrest situation in Assam. Based on an analysis of the available facts and figures, the paper ends with a set of suggestions which might help in solving the basic problems behind the long-drawn turmoil in the state.

P. Pathak

Statistical Models for Finding out Determinants of Absorption in Jobs for Different Categories of Labour in Uttar Pradesh, Punjab and Haryana

By making use of the 50th Round NSS data on employment and unemployment, the study attempts at finding out through statistical modeling the determinants of labour absorption in Uttar Pradesh, Punjaband Haryana. The determinants have been obtained for salaried workers, own account workers, employers and casual workers.

P. Pathak

The Scope of Utilising Telemedicine for Improving the Functioning of the Indian Public Health System in the Prevalent Socio-economic and Cultural Scenario

Keeping in view the National Health Plan, 1983 and the reformulated National Health Plan, 2002, the paper assesses critically the deficiencies in the Indian public health system and explains how and in what form, telemedicine can improve the functioning of the system in the coming years through effective and efficient sharing of information.

P. Pathak

Study of the knowledge, attitude and participation of elected panchayat members in health and family welfare programmes in West Bengal

In regard to the knowledge of the panchayat members, eighty per cent respondents, on the average, were knowledgeable about the educational institutions, public and private health facilities. Regarding the involvement of the panchayat members in the public health affairs as per government directives, the panchayat members were involved in promoting health awareness among people, child immunisation, safe drinking water, motivating people about the acceptance of family planning methods, participating in the government run health programmes and arranging for treatment of the rural people. Suggestions of the panchayat members regarding the measures needed to reduce population growth of the country highlights their willful efforts to solve the problem.

S. Barman

Spatial study of Reproductive Health Services : An Analysis of various Reproductive Health Survey Data

This study will assess needs and utilisation of reproductive and child health services at the individual level. Based on this information, a strategy has to be developed for programme planners and policy makers to deliver quality of services at the grassroot level.

B.N. Bhattacharya

An Approach to estimate the Very Young Ages of Indian Census Population, 1991

Adjustments to very young age group of Indian raw census age distribution were left undone by some demographers/actuaries in the past because of large extent of error and undercounting per se while adjusting the whole set. The present study as such tries to adjust this particular group on the basis of framing regression model using other age groups assuming a relation between fertility and mortality in the recent past under stable condition.

B.K. Mukhopadhyay and P.K. Majumdar

Adjustment to single year data on age: a new approach

The present work is based on number of steps starting from cumulation of the grouped raw data once in a more than type and other in a less than type to get a smooth single year data. However some more adjustment is done by fitting 3rd degree polynomial which fits well ($p < 0.00$) The adjusted single year data for male and female populations of India are consistent. The present technique is easier than other existing techniques which usually performed differently for different sectors of ages.

B.K. Mukhopadhyay and P.K. Majumdar

Study of Mother and Child Health Care

Indepth Study of Antenatal and Postnatal Care of Mother and Child from National Family Health Survey, NFHS1 and NFHS2. The study reveals the status of immunisation given to mother in antenatal period and to children in postnatal period. This also highlights the comparison of immunisation status between NFHS1 and NFHS2.

S. Sadhu and B.N. Bhattacharya

Psychology Research Unit

Research and other Scientific Activities

A Study of Organizational health and job satisfaction in rural banks from psychological perspective

In studying organizational health of rural bank, usually attention was paid to financial parameters ignoring bank as socio-technical system. Current study defined organizational health from psychological perspective and explored several parameters to assess physical, mental, social and spiritual health of organization. Results revealed relative importance of different Organizational health predictors in predicting different levels of job satisfaction of employees in the regional rural, commercial and cooperative banks in the rural areas.

D. Dutta Roy and S. Mukhopadhyay

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

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

D. Dutta Roy and M. Maitra

Team effectiveness in work settings

The objective of the study is to find out the importance of relevant psychological factors in teamwork and to know their impact on the efficiency of the team. Individual level and group level variables have

been taken into consideration to have an understanding of their impact on team efficiency. Data are being collected from different IT companies located at different parts of India.

A. Ghosh and M. Sharma

Social Axioms and Individualism-collectivism

Social Axioms are general beliefs about material, personal, social and spiritual reality that are held by a person and are likely to relate to a wide range of social behaviours across different contexts. In this study the pattern of relationship between different dimensions of social axioms and individualistic-collectivist orientations was studied in college students coming from different regions of India. Findings showed that students with high individualistic orientations were found to reflect high social cynicism and reward for application. Significant effect of gender and culture was also observed on different dimensions of social axioms.

A. Ghosh

Analysis of drawing of tribal children

In analysis of drawing by the children, usually attention was paid to bounded drawing (draw a fixed object or person) resulting in gap of knowledge about one's preference to draw and associated feelings. Current study developed a new methodology to assess unbounded mode of drawing. Three layers of consciousness – outer, inner and innermost core were assessed through this new scoring procedure. Data were collected from the children rearing remote villages of Tripura. Results revealed emotional disturbances among the tribal children. Their outer layer of consciousness was more organized than the inner and innermost cores. The findings are important for psychological counseling to the children in primary education.

D. Dutta Roy

Training-Impact study

Training impact on workers' knowledge and attitude to training and company performance were examined. Training was imparted by the education officers of Central Board for Workers Education of the Ministry of Labour to the workers of a Jute mill. The results revealed significant change in different objective parameters (productivity, wastage control, accident, absenteeism, etc.) and the subjective parameters (Achievement scores in several areas of knowledge in jute manufacturing process) during the training programme as compared to earlier.

A. Ghosh, D. Dutta Roy and R. Gupta

Clustering state anxiety scores

There is much controversy about anxiety susceptible months in the Antarctica due to rapid fluctuation of environmental and psychological stress inducing conditions. Current study examined this issue by clustering State anxiety scores across twelve months of Antarctic expedition using complete linkage cluster analysis. Dendogram revealed two clusters named as isolation experience and adaptive experience. The results are important for psychological counselling to the Antarctic expeditioners.

D. Dutta Roy

Socialization and Cognitive-moral development of Children across cultures

The purpose of the study was to find out the relationship between cultural dimensions, parental socialization and cognitive moral development of children across different cultures. Data were collected from school children at two different stages of development and from two different cultural settings. One of the parents of the children were also interviewed. The results of the study revealed that both culture and developmental changes have significant effect on the moral development of children.

A. Ghosh

A study on Preferences to Different Reading and Writing motives of Tribal Children in Primary Education of Tripura and Manipur

Questionnaires were translated into different local tribal languages of Tripura and Manipur. Item validity was made in the different workshops conducted in both states with the primary school teachers and education officers. In the workshops, participants were trained how to teach and manage the students for development of more reading and writing motivation.

D. Dutta Roy and R. Gupta

External Evaluation of State Resource Centre, Patna (ADRI) Bihar

External evaluation of State Resource Centre (SRC)-ADRI-Bihar was done with respect to eight components : training, materials, outreach/extension activities, innovative programmes, research and evaluation, networking, management and administration and finance. In-depth studies of the different components indicate that the S.R.C. has excelled in building up the optimum environment through several innovative programmes, by preparing materials, organizing training programmes and networking in implementing literacy programme in several districts of Bihar.

A.Ghosh (PSY), A. Dasgupta, A.K. Ghosh and D.Sen (Sociological Research Unit) and P.K. Majumdar and S. Dihidar (Population Studies Unit)

Sociological Research Unit

Research Activities

SRU has been carrying out several internal and external research projects in the following themes which have relevance for understanding various processes of social transformation and comparative development in the country:

Agrarian relations and rural development,
Decentralisation of planning process,
Evaluation of socio-economic impact of literacy movement,
Religious and ethnic problems and
Empowerment of women.

New methodological research for social network analysis by using probabilistic and graph theoretic techniques

These research themes, with empirical thrusts, have been taken up by SRU mostly at H.Q. in Kolkata covering West Bengal and partly at Giridih branch in Jharkhand as well as in Tamil Nadu, Tripura and Meghalaya.

Economic reforms and Indian agriculture in North-East

The project attempts to study the impact of economic reforms on the agrarian economies of the North-East and disseminate, by means of a workshop to be held in a university in North-East, the results of the empirical research and develop a research agenda specific to the North-East. The workshop in Shillong has been held recently.

V.K. Ramachandran, M. Swaminathan and D.Sen

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

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

M. Chattopadhyay and M. Swaminathan

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

The objectives of the project are to investigate whether villagers find congenial support base in the network of interpersonal relations in the changing socio-economic situation of West Bengal and to locate the role of 'social connections' in facilitating or constraining the scope of educational attainment and development of skills to get access to socio-economic opportunities. The field work is nearing completion.

A.K. Chatterjee and D. Bhattacharya

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

The objective of the study is to understand the pace, perception as well as process of empowerment of women belonging to different categories in rural societies in Meghalaya and Tripura. The collection of field data is nearing completion.

B.N. Ghosh and A.K. Ghosh

Projects in Giridih Branch :

In Giridih, SRU has undertaken five projects: the first project seeks to examine the responses of the urban and rural households to macro processes related to the decline of mica industry in Giridih town including the consequences on the gender issue; the second project envisages an empirical study of marginalization of women workers in mica industry, analyzing the segregation of female workers in terms of their concentration in unskilled jobs as well as in the context of variation in their wages; the third project aims at exploring potential power structure with emphasis on social network in selected villages of Jharkhand; the objective of the fourth project is to investigate and compare the pattern of social relations under influence of factors like higher castes, feudal forces and *Panchayati raj* in some selected villages in Jharkhand and West Bengal; and the fifth project aims at an empirical study of the impact of economic reforms on rural credit markets in selected villages of Jharkhand. The technical reports on all the above projects have either been completed or are nearing completion. The publications have already come out on the first, the second and the fifth project.

V.K. Ramachandran, Anil Chaudhuri and Molly Chattopadhyay

Externally funded projects

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

The project report has been completed.

A. Dasgupta

Study on status of women in West Bengal (funded by the State Women's Commission, Government of West Bengal)

The project report has been completed and a publication has come out in January 2005.

A. Dasgupta

External evaluation of Total Literacy activities in West Tripura and Dhalai districts of Tripura (funded by State Resource Centre, Tripura and the Zila Saksharata Samitis of West Tripura and Dhalai districts of Tripura)

The external evaluation has recently been completed. Interim reports have been submitted. The final reports are going to be submitted soon.

A. Dasgupta

Evaluation of State Resource Centre of National Literacy Mission in Bihar (funded by National Literacy Mission, Ministry of HRD, Govt. of India)

This project was undertaken jointly by Psychology Research Unit, Sociological Research Unit and Population Studies Unit. The project report has been submitted.

A.Ghosh, A. Dasgupta, A.K. Ghosh and D. Sen

Statistical Quality Control and Operations Research Division

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

The main activities of the Division were research, teaching, consultancy and training. Conducting M.Tech.(QROR) programme at Kolkata and Part-Time Certificate courses at Bangalore and Hyderabad were other responsibilities of the division. The faculty members of the division also taught in various academic programmes of ISI. They have supervised dissertation and project work by M.Stat. and M.Tech.(QROR) students.

The Division organised (i) Winter School on Operations Research and its Applications, (ii) National conference on Tools and Techniques for Quality and Productivity Improvement and (iii) The Golden Jubilee conference to commemorate 50 years of SQC and OR Unit, Bangalore. One programme was conducted in the North-East. Faculty members of the Division were in the organizing committee of an international conference and attended a number of conferences and delivered invited talks.

Training and consultancy were other major areas of work for the divisional faculty members. The Division extended its consultancy and training services to about 150 organisations during 2004-2005. The division organised more than 150 training programme covering over 3300 participants at various levels –top management, senior management, executives/engineers and supervisory staff. The topics for consultancy and training included SPC, simple tools of QC, DOE and Taguchi methods, Six sigma awareness, Six sigma theory and implementation, Green belt, Black belt training, QM systems awareness, reliability, quantitative techniques, market research, internal auditing for ISO 9001 : 2000, statistical techniques for software quality, time series, TQM, quality in education, MSA, etc. The software sector emerged as the new area where the division's consultancy was highly appreciated. Some important organizations served were : ITC, L&T, Reliance Industries, IKCO Iran, Infosys, Novel, Wipro, Infotech, AC Nelson –ORG MARG, BHEL, Marmugao Port Trust, ICICI securities, State Bank of India (I & A Dept.) Hyderabad. Consultancy and training was also provided to a number of countries such as Iran, Saudi Arabia, Dubai, Philippines, Hong Kong, Thailand, Taiwan and Germany.

During this period twenty five papers were published and eight papers were accepted for publication in reputed journals.

Areas of Research Activities:

Evaluation of non-normal process capability indices using generalized Lambda distribution. Acceptance sampling for multivariate characteristics, software Quality Metrics, Economic design of control chart when process failure follows logarithmic series distribution, Linear models, Regression analysis and diagnostics. Mathematical programming, LCP, SDLCP, Non-co-operative games, Cone complementarity over Jordan Algebra, Stochastic Games, Visual Cryptography. Problems of change point of life time distributions, Software Reliability, Consecutive K-out-of-N : F System.

Divisional Publications

The Bangalore unit continued publication of the divisional NEWS LETTER and brought out three volumes in 2004 - 05.

U. N. Acharya, A. K. Chaudhuri (eds)

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

SQC & OR Unit, Bangalore

Teaching and Training

The staff members of the unit organized, co-ordinated and provided faculty support to ISI Bangalore's regular Part time Certificate Course in SQC, for January – June 2004 and July - December 2004 batches. January – June 2005 batch is running presently.

Research and other scientific activities

Semi definite linear complementarity problems

In this area we consider problems related to semi-definite linear complementarity. In particular, we are investigating P-property and Gus property and the Lipschitz properties of the solution map of the SDLCP. We also propose to explore numerical methods for solving the SDLCP.

Evolutionary games

In this work, we are trying to look at Game theory from an Evolutionary point of view. We are considering various points of view, and working on how evolutionary strategies may be derived from individual level models.

G. Ravindran

Software Quality Management and Six Sigma

This research work is primarily aimed at improving intrinsic capabilities of various software processes using Six Sigma, Lean and Project Management concepts. In this work we plan to include development of a Process Model and Step-by-Step Methodology for the different Objectives identified. We also intended to develop softwares for use based on statistical modeling of data.

M. Chinnagiri

Externally Funded In-Plant Training Programmes

Sl. No.	Organization	Title of the Programme	No. of Participants
1	ABC Business solutions Ltd., Delhi	Six Sigma Training for Green Belts for Saudi Arabia and Dubai participants (3 Batches)	60
2	AC Neilson ORG Marg, Baroda; L & T, Mysore (Ongoing)	Six Sigma Training for Black Belts	45
3	Ashok Leyland, Chennai; BEML, Bangalore	Top Management Program on Six-Sigma – ISI Approach	25
4	AT & S, Mysore	Internal Auditor Program for TS 16949-2002 Quality Management Systems, Six Sigma Training for Green Belts, Statistical Process Control, Measurement Systems Analysis	110