ISI SIXTYSECOND ANNUAL REPORT

1993-94

Indian Statistical Institute
203 Barrackpore Trunk Road
Calcutta 700 035

INDIAN STATISTICAL INSTITUTE

Annual Report
April 1993 - March 1994

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BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early twenties through the pioneering initiative and efforts of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological and Anthropological Survey of India) and subsequent interactions with him led to Mahalanobis' first scientific paper 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 were picked up by him in the Department of Physics, Presidency College, Calcutta, where he was a Professor. This group formed the nucleus of a laboratory which later came to be known as the Statistical Laboratory.

In the early thirties, realising the necessity for a concerted effort for the advancement of theoretical and applied statistics in India, Professor Mahalanobis together with Professors P.N. Banerjee 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 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 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 organisation which now has around 1600 workers, including about 500 scientific workers. The Institute has its headquarters in Calcutta and two other Centres at Delhi and Bangalore and a branch at Giridih. It also has a network of service units of Statistical Quality Control and Operations Research Division at Baroda, Bombay, Trivandrum, Pune, Coimbatore, Madras, Hyderabad in addition to Calcutta, Delhi and Bangalore.

From the very beginning, Professor Mahalanobis and his associates who included Professors S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen and H.C. Sinha worked with zeal and enthusiasm for the development of statistical theory and methods, and in promoting research and practical 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. 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 by Professor C.R. Rao and many others who joined the Institute in the forties. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale agricultural enquiries. This led to a large number of 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, and in securing a separate section for Statistics in the Indian Science Congress.

Activities of the Institute gained further momentum from 1938. Professor Mahalanobis started sample surveys to estimate the area under jute crop in Bengal in 1937 as an exploratory work, which later grew to a full-scale survey of the entire province in 1941. 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) division was started for conducting socio-economic surveys of all-India coverage on a continuing basis. The ISI group on sample surveys served as the Technical Wing of the NSS from 1950 till it was transferred to the Government of India in 1972.

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The ISI 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 1948 and later by inviting other experts like W.E. Deming for the same purpose. 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 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. Research in other disciplines of Social Sciences was also started in the Institute in the late fifties. Professor Mahalanobis' 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. Earlier, the well known Y-sample estimates for 1941 Census population were also derived by the ISI. Theoretical and empirical research in sociology using statistical techniques was started in the Institute for the first time in south-east Asia. Similarly, the development and introduction of psychometric tests for selection processes in different organisations was first made by the ISI in India besides carrying out basic research in Psychometry. The studies of the phonetic structure of some major India languages have been made on a continuing basis in the Institute under the guidance and collaboration of the famous linguist Djordje Kostic.

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 theoretical statistician one must also 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. In 1958, a digital computer URAL was received as a gift from U.S.S.R. Since 1956 till mid sixties, the Institute had been serving as a de facto national computer centre for the country. In early sixties, the Institute, in collaboration with the Jadavpur University, undertook the design, development and fabrication of a fully transistorised digital computer, called ISIJU-1 which was commissioned in 1966 by Shri M. C. Chagla, the then Minister of Education, Government of India.

Quantitative analysis in Physical and Earth Sciences was one of the novel ideas of Professor Mahalanobis pursued in the true spirit of the Institute. In addition to evolving some interesting techniques and obtaining some very interesting results from the analysis of directional geological data, the Institute also made a significant contribution by discovering the bones of a 16m (+) long sauropod dinosaur, *Barapasaurus tagoreli*, from the lower Jurassic Kota rocks near Sironcha, Gadchiroli district, Maharashtra, in the sixties. The animal has helped in understanding the interesting problem about the origin and evolution of sauropod dinosaurs. It, in fact, represents the only intermediate form between the prosauropods and the sauropods, and is called a "missing link" in the evolution of the sauropod dinosaur.

The Institute expanded its research, teaching, training and project activities and earned national and international recognition over time. The substantial contributions of the Institute to the quality of theoretical and applied statistical work have culminated in the recognition of the Institute by the Government of India enacting "The Indian Statistical Institute Act, 1959" (No.57) which declared the Institute as an "Institution of National Importance" and empowered it to award degrees and diplomas. None other than Pandit Jawaharlal Nehru, the then Prime Minister of India, piloted the bill in the Parliament. With this recognition, the already existing teaching and training programmes were consolidated and expanded and courses for the degrees of Bachelor of Statistics [B.Stat. (Honours)] and Master of Statistics (M.Stat.) were started from June 1960. The Institute was also empowered to award Ph.D./D.Sc. degrees from the same time. Later on, courses leading to Master of Technology degrees were started in Computer Science and in Quality, Reliability and Operations Research.

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The role and importance of ISI in conducting and promoting teaching of statistics has been appreciated by international bodies as well. In 1950, the International Statistical Institute had initiated, jointly with the ISI, the International Statistical Education Centre (ISEC), Calcutta, to impart training in Theoretical and Applied Statistics to selected participants from developing countries. The centre is run under the auspices of the UNESCO and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater encouragement to research activities not only in statistics and mathematics but also in various branches of the natural and social sciences, without whose live contact, it was believed, the methodology of statistics could not grow to its current level. It is also due to this fact that "Unity in Diversity" is adopted as the motto of the Institute.

The objectives of the Institute as laid down in the Memorandum of Association of 1976 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; and

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.

From the early days, the Institute has been in touch with many internationally famous scientists in different disciplines from the world over. 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 it considerable support. Professor J.B.S. Haldane, a geneticist of international repute, was a member of the faculty for several years beginning 1957. At the inspiration of these stalwarts and other renowned scientists, the Institute began to expand and/or undertake research activities in several areas of natural and social sciences with the hope that collaboration under the same roof would foster the mutual development of statistics and other disciplines. In fact, the Institute stood up to Sir Ronald Fisher who called Statistics 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.

Coming to more recent times, the Institute has continued to pursue its goal of attainment of excellence in the various fields of science. Fundamental research in statistics with its roots in applications has been bottom the line ever since the inception of the Institute. The contributions from the Institute in multivariate analysis, design and analysis of experiments, sample surveys, statistical methods of data analysis and statistical inference have found their places in text books and monographs, and the tradition continues. In addition, probability theory and stochastic processes have also been major areas of research in the Institute. The theoretical mathematicians of the Institute, in addition to collaborating with the statisticians, are also making fundamental contributions in several fields - topology, functional analysis, harmonic analysis, algebra, combinatorics, quantum mechanics, game theory, to name some. The current trend of research in statistics not only carries forward the traditions set up in the Institute, but is also setting new directions, both in theory and applications, in different disciplines.

The Institute has been maintaining its tradition of high quality research and development in the field of computer science. In 1979, a microprogrammed signal processing system using FFT was designed and developed. Keeping pace with the global advances in computer technology, the activities of the Institute in the field of computer science gathered a tremendous momentum in the late seventies, resulting in diversification of research in different areas including Algorithms and Complexity, Parallel and Distributed Processing, Fault-Tolerant Computing, VLSI, Computational Geometry, Fuzzy Sets and Systems, Cybernetics, Pattern Recognition, Neural Nets, Artificial Intelligence, Image Processing, Computer Vision, Particle Physics, Fluid dynamics, Plasma physics etc. In recognition of its contributions in the field of computer science, the Government of India established, in collaboration with the United Nations Development Programme (UNDP),

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one of the five national Nodal Centres for Knowledge Based Computing Systems (NCKBCS) in ISI in the year 1988.

The different disciplines under the Social Sciences also continued to develop and flourish over time by carrying out basic research as well as inter and multi-disciplinary work. In economics, the Institute has come to be known as a specilised centre for its significant contributions in different branches of theory and also for studies on such areas as 'Demand Analysis, Poverty and Levels of Living, Measurement of Inequalities, Production and Prices, National Income and Allied topics, Development and Planning etc. In Demography, Sociology, Psychometry and Linguistics also the Institute maintained its distinctive feature for the focus and emphasis on quantitative aspects. Mention may be made, in this context, about the pioneering theory for teaching and training, developed by Prof. Kostic, for the hearing-impaired children. Based on this theory the Electronics Unit of the Institute, in collaboration with the Linguistic Research Unit and the Government of Tripura, designed, developed and fabricated a set of instruments for the hard-of-hearing children of the Institute of Speech Rehabilitation, Government of Tripura, Agartala. This has come to be regarded as having significant impact on social welfare.

Plant and human biology have been the major areas of research in biological sciences. Both basic and applied research are conducted, with emphasis on quantification, statistical design and analysis, and modelling. In the area of plant biology, research has included quantification of natural variability and modelling, animal behaviour, effect of interaction of rice varieties on yield, use of protein extracted from leaves to supplement human food, mathematical modelling of ecological and embryological phenomena, etc. In the area of human biology, researches have included anthropometric, genetic and biochemical studies on population affinities, micro-evolution, studies on utilising data on anthropometric variability in designing car seats, human adaptation to differring environments, human ecology and growth and genetic epidemiology.

Over the years, the SQC & OR Division has grown to the size of having 11 operating units all over the country and have uniquely served for promotion, education & training and technical guidance in Quality Management, TQC Methodology, Quality Assurance Systems for the benefit of the manufacturing and service industry over the decades. It has thus, as was intended, played a leading role in dissemination of new concepts, methods and techniques in the area of Quality and Productivity.

The Central Library of the Institute is located at Calcutta with a network extending to other locations of the Institute. Over the years, the library of the Institute has attained the distinction of being one of the richest libraries in the country, particularly in the fields of statistics and related disciplines. The library has developed a well-equipped Reprography and Photography Unit. The library's gift collections include the personal libraries of Professor P.C. Mahalanobis and Professor Walter A Shewhart. The library has been recognised as the Depository Library for World Bank publications. A separate collection of books and journals in Mathematics, Statistics etc., known as Eastern Regional Centre of NBHM has been developed out of the grants from the National Board of Higher Mathematics.

The Documentation Research and Training Centre (DRTC) established at Bangalore in 1962 by the late Professor S.R. Ranganathan, a doyen in the field of library and information science, is engaged in research, teaching and training in the documentation and information science. The Institute awards post-graduate diplomas in documentation science.

An index of the contributions of the Institute is the publication of about 30 books and monographs, in addition to several hundreds of scientific papers in national and international journals, in the recent past, receipt of national and international recognitions of very high order by scientists of the Institute by way of awards, titles, and fellowships, and holding of prestigious positions in various scientific organisations of higher learning as well as in governmental organisations not only in India but also in several international organisations. With a dynamic group pursuing and guiding research work in some of the most modern topics in statistics, mathematics and in various fields of natural and social sciences, there is close interaction with scientists from all over the world.

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DIRECTOR'S REPORT

The year under reporting was special in the history of the Indian Statistical Institute being the birth centenary year of the Founder-Director Professor Prasanta Chandra Mahalanobis. His birth centenary fell on 29 June 1993. To mark and celebrate the special day a variety of functions were held. A special function, chaired by the Hon'ble Prime Minister of India, Shri P. V. Narasimha Rao, was held. Shri Jyoti Basu, Hon'ble Chief Minister of West Bengal, Central Ministers Shri Pranab Mukherjee, Shri Giridhar Gomango and Shri Sukh Ram, were also present on the occasion. Hon'ble Shri Narasimha Rao released a commemorative stamp of Professor Mahalanobis in the denomination of one rupee. Later, he unveiled a bust of Professor Mahalanobis and opened the Mahalanobis archive-cum-museum. He also inaugurated a special conference on 'Planning and Economic Policy in India' as a part of the centenary celebration.

In continuation of the celebration several other conferences/symposia were organized besides the conference on "Planning and Economic Policy in India". The Third International Conference on "Advances in Pattern Recognition and Digital Techniques" was organized by the Electronics and Communication Sciences Unit during 28 - 31 December, 1993. The Theoretical Statistics and Mathematics Unit at Calcutta organized an International Conference on "Environmental Problems : Issues, Statistical Models and Methods" during 20 - 22 December, 1993. The Unit in collaboration with Computer Science Unit also organized a National Symposium on "Sample Surveys" during 15 - 17 December, 1993. The Anthropology and Human Genetics Unit organized a lecture series on "Frontier of Anthropology" to celebrate the birth centenary as well as to commemorate the Silver Jubilee of the Unit in December 1993. The Sociological Research Unit organized a National Conference on "Social Transformation : Different Dimension" at Giridih. A special lecture was delivered by Professor P. V. Sukhatme entitled "A New Dimension to the Poverty Problem of the Country" on 6 November 1993 at Calcutta as a part of the celebration.

Different branches of Institute also celebrated the centenary by organizing special function on the occasion. A special function chaired by Dr. S. Sathika, Vice-Chancellor of the Madras University was organized by the SQC/OR Unit of Madras on June 25, 1993. At the function, the new premises of the Unit was inaugurated and dedicated to Professor Mahalanobis. A video film with the title "Quality: Our Own Heritage" was released by Dr. Sathika and was presented to Professor M. G. K. Menon, President of the Institute. At Trivandrum, a half-day symposium on "Statistical Sciences for National Development" was organized by the SQC/OR Unit, jointly with NSSO (Kerala) and other organizations dealing with Statistics and its applications.

To mark the occasion of birth centenary a documentary film with the title "Tale of a Savant" was produced by the Institute and was telecast by the Doordarshan on national network on 30 June, 1993. Calcutta Doordarshan also produced and telecast a documentary film entitled "Prasanta Chandra Mahalanobis : A Doyen of Indian Science".

During the year the Institute as usual organized several other national and international conferences, workshops, summer and winter schools at different centres on a variety of subjects besides the special conferences/symposiums. Mention may be made of a Winter School on "Logic Programming" and a UGC sponsored Refresher Course in Statistics by the Theoretical Statistics and Mathematics Unit at Calcutta, a five-day Workshop on "Neuro-Computing, Pattern Recognition and Computer Vision" by the Machine Intelligence Unit (jointly with the Electronic Research and Development Centre) and a Workshop on "Frontiers of Research in Finite Population Inference" by the Theoretical Statistics and Mathematics Unit at Calcutta. A seminar on "Library Network in India" was organized by the Documentation Research and Training Centre jointly with INSDOC at Bangalore during August 1993 and two in-plant courses on "Quality Management" and "New Seven Tools in Quality" was organized by the SQC & OR Unit at Baroda.

As a recognition of high research standards and scientific excellence maintained by the researchers of the Institute, several faculty members received laurels in the form of awards and fellowships during the year.

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Professor K. B. Sinha of Theoretical Statistics and Mathematics Unit, Delhi and Professor Sankar Pal of Machine Intelligence Unit were elected as Fellows of the Indian National Science Academy. Professor Pal also received the prestigious Jawaharlal Nehru Fellowship for the year 1993. Professor Rajeev Karandikar of Theoretical Statistics and Mathematics Unit of Delhi was elected Fellow of the Indian Academy of Sciences. Several other younger faculty received Young Scientists awards and fellowships from scientific bodies such as Indian Science Congress Association, Institute of Electronic and Telecommunication Engineers, International Society for Scientometrics and Informatics etc.

Keeping the idea to maintain the high perfection and excellence of the Institute in the national as well as international scientific scenario in view, research activities were in full swing during the past year. Research and training in core areas of Statistics, Mathematics, Economics, Computer Science, Electronics and Communication Sciences and other related fields are also in full gear. Active work on a number of inter-disciplinary projects by applied statisticians, economists, sociologists, biologists etc. were undertaken. The Geological Studies Unit discovered important and very well preserved fossil amphibians from the Denwa formation of the Satpura Gondowana basin. Under FYF-LC Project on improvement of health and economic status, intervention programme using Leaf Concentrates (LC) was undertaken by the Leaf Protein Unit. The Planning Unit undertook a project, sponsored by the Ministry of Industries, Government of India on "Industrial Sickness in India". The report of the project attracted a good deal of attention. Another project sponsored by the Indo-Dutch Programme on "Alternatives in Development" to study "India's Exports to European Community : Constraints and Prospective" is under progress. The project is aimed at studying the prospects and constraints of India's exports in the light of recent economic policy initiated by the Government. A project " Procedures for Spectral Characterization" that has physical meaning for reduction of features in multispectral remote sensing data was sponsored by Defence Electronics Application Laboratory. The Sociological Research Unit completed the study to gauze the impact of literacy campaign in Bankura and Birbhum.

In the changed atmosphere of promoting export and improvement of product quality, the use of Statistical Quality Control and Operation Research and allied management techniques in controlling loss and cost, improving and augmenting productivity in industries is absolutely necessary. This has been felt strongly by the Indian industrialists and the nationwide awareness has opened up a vast opportunity for the SQC and OR movement in the country. To-cater to this demand, the SQC and OR Unit went ahead in academic programmes, consultancy services, in-plant and general training courses for people from industry and research in the methods and procedures of quality control and allied programmes, i.e., ISO-9000 and Total Quality Management (TQM) programmes etc.

Regarding teaching and training activities during the year, 9925 candidates applied for admission to various courses of the Institute including B.Stat. (Honours), M.Stat. (M- and S-streams), M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research). Out of the total applicants, 5896 appeared for the admission test and finally 218 were selected after written test and interview for the academic session 1993-94. Five foreign students applied for admission to these courses through test conducted at the Indian Embassies. The Examination Committee of the Institute conducted professional examinations in Statistics for award of Diploma in Statistics in June and December 1993. Nine candidates out of seventy-two passed in one or more papers in these examinations.

The International Statistical Education Centre started functioning in 1950. The Institute operates the Centre jointly with the International Statistical Institute under the sponsorship of UNESCO and the Government of India. The Centre is conducting its forty-seventh term with 13 foreign and 2 Indian trainees.

As far as the financial position is concerned, there is no perceptible change. Problems of fund position remain as before. Institute is not able to provide sufficient funds even for some nationally important projects. However, it should be mentioned that scientists should also look for and work in projects which have national if not global implications rather than on projects of limited relevance or value. The memorandum of the Institute gives very little chance for optimisation of resources under the present set up. Library problems remain which need no longer be emphasized. From the limited resources available, a reasonable amount for the Library was apportioned. Thanks to the efforts of all the workers, the accounts were closed in a reasonable time and the Institute was able to submit the Annual Report by November 15, 1993. Cash flow problems were less as compared to last year.

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On the administrative side, the problem of embargo on recruitment from outside imposed by the Government remains. Partial lifting of embargo for specific posts by allowing recruitment on a temporary basis has not eased the problems. Several middle level officers in the administration have retired. It is important that new blood is inducted to give a boost to efficiency. It should be recognized by one and all that the Institute by its very nature is involved in study and dissemination of knowledge of statistics, is to undertake research in natural and social sciences for development of statistics and other sciences and finally to undertake projects for the purpose of planning and the improvement of efficiency of management and production. In order to achieve these objectives, it is necessary for the Institute to employ people on time bound projects. Employment of this type is temporary in nature by the very definition and it is just not posssible for the Institute to regularise such temporary jobs. This should be recognized by one and all. If there is no agreement on this, projects are bound to suffer in the long run.

Indian Statistical Institute is internationally recognized as a centre of excellence both for its theoretical contributions to Statistics as well as applications of Statistics. We hope to have continued cooperation from the Department of Statistics and Ministry of Planning as it is an academic institute under their wing for which they can be proud of.

Calcutta   *B.L.S. PRAKASA RAO*
31 March, 1994

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

1. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities during the period from April 1993 to March 1994 is given below ·

During the academic session 1993-94, 9925 candidates applied for admission and were called for written selection tests for the various courses offered by the Institute. The courses and fellowships for which admission was sought this year were - B.Stat. (Hons.), M.Stat. (M-Stream and S-stream), M.Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, Two-year part-time post-graduate Diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Computer Science, Physics, Applied Mathematics and Fluid Mechanics, Anthropology, Geology, Physiology, Electronic Communication Science and Theoretical Computer Science, One Year Part-time Course in Statistical Methods and Applications and the course on Operation and Programming of Automatic Data Processing Equipment. Admission tests were conducted at 22 different centres all over the country. A total of 5896 candidates finally appeared for admission tests and a total of 424 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 218 candidates were offered admission to various courses during the academic session under review.

There were five foreign students who applied for admission to these courses. Admission tests were conducted for them through the Indian High Commission/Embassy in Dhaka and Kathmandu.

The annual examinations for all the regular courses were held in May/June 1993. The 1993-94 academic session commenced on 5 July, 1993.

Fourteen trainees in Engineering and Technology from various Universities (Jadavpur, IIT, Kharagpur, M.N.R.E. College, Allahabad, College of Engg., Burla, R.E.College,Kurukshetra and S.V.U. College of training, Tirupati) received a four to six-week practical training in the Electronics and Communication Sciences Unit, the Machine Intelligence Unit, the Computer and Statistical Services Centre and the Electronics Unit.

One hundred and seven candidates received their degrees and diplomas at the Twentyeight Annual Convocation of the Indian Statistical Institute held on 11 February, 1994 and 92 candidates who passed the various regular courses of varying durations (one year or less) received the certificates during the year. Eleven Research Fellows were awarded Ph.D. degree of the Indian Statistical Institute and two Research Fellow were awarded Doctoral Degree by Jadavpur University & Calcutta University for work done in ISI during 1993-94.

The number of candidates admitted to the different degree, diploma and training courses in 1992-93 and 1993-94 and the number of students passed in the annual examinations in 1993 are given below.

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NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

Courses	Number of Students		
	Enrolled in 1992-93	Passed in the annual exam in 1993	Enrolled in 1993-94
(1)	(2)	(3)	(4)

Degree

1. Bachelor of statistics
   with Honours
   [B.Stat.(Hons.)]

1st year	23	22	10
2nd year	13	12	22
3rd year	22	22	12

2. Master of statistics
   (M.Stat.)

1st year (M-Stream)	9	4	12
1st year (S-Stream)	18	17	25
2nd year	22	22	21

3. M.Tech. in Computer Science

1st year	21	17	19
2nd year	20	20	17

4. M.Tech. in Quality, Reliability
   and Operations Research

1st year	17	12	19
2nd year	13	12	12

Diploma\Certificate\Associateship

5. Course on Operation and
   Programming of Automatic
   Data Processing Equipment

1st year	12	12	8
2nd year	5	5	12

6. Part-time Certificate\Diploma in
   Statistical Quality Control and
   Operations Research (Bombay
   and Madras)

Bombay - 1st year and 2nd yrs	•		■
Madras - 1st year	10	6	12
2nd year	6	4	10

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	(1)	(2)	(3)	(4)
7.	Associateship in Documentation and Information Science			
	1st year	*	-	9
	2nd year	7	7	*
8.	Part-time course in Statistical Methods and Applications			
	Calcutta	43	5	16
	Delhi	*	-	16
	Hyderabad		+	-
9.	Six-month Part-time Course in Statistical Quality Control			
	Bangalore - Jan. - June	15	12	16
	July - Dec.	18	16	27
	Hyderabad - Jan. - June	9	7	9
	July - Dec.	7	6	-
10.	Intensive Course in Programming and Applications of Electronic Computers	21	17	10
11.	Junior Certificate Course in Statistics (Jointly with C.S.O.)	*	-	*
Fellowship				
12.	Junior and Senior Research Fellows, Visiting Fellows in different d isciplines	138	11 **	140
13.	SDP Fellows	2	-	*
	Grand Total	520	268	454

* Course not offered   + Result yet to be announced

** Awarded Ph.D. in 1993

Ph.D./D.Sc. Degrees Awarded

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

(i) Arvind Kumar Lal
"Coxeter groups and positive matrices".
Supervisor : R.B. Bapat, ISI, Delhi.

(ii) Anusharka Sen
"Some limit theorems on conditional U-Statistics and censored data non-parametric regression".
Supervisor : B.L.S. Prakasa Rao, ISI, Calcutta.

(iii) Anindita Mukherjee
"Rural labour markets and seasonality : A theoretical and empirical analysis".
Supervisor : Debraj Ray, Boston University, USA.

(iv) R. Sridhar
"Exact order matrices and the linear complementarity problem
Supervisor : S.R. Mohan, ISI, Delhi.

(v) B.V. Rajarama Bhat
"Markov dilations of nonconservative quantum dynamical semi groups and a quantum boundary theory".
Supervisor : K.R. Parthasarathy, ISI, Delhi.

(vi) Abhay Gopal Bhatt
"On Markov processes charaterised via martingale problems".
Supervisor : R.L. Karandikar, ISI, Delhi.

(vii) Prasanta Pathak
"Diagnostic regional analysis on the shortfalls in developement and utilisation of human resources in India".
Supervisor : M.N. Pal, ISI, Calcutta.

(viii) Ashish Ghosh
"On image segmentation using neural networks and fuzzy sets".
Supervisor : Sankar Pal, ISI, Calcutta.

(ix) K. Manjunatha Prasad
"Generalised inverses of matrices over rings".
Supervisor : K.P.S. Bhaskar Rao, ISI, Bangalore.

(x) Prabal Ray Chaudhuri
"Joint Ventures and Bargaining"
Supervisor : Dilip Mukherjee, ISI, Delhi.

(xi) Deba Prasad Mandal
"A multivalued approach for uncertainty management in pattern recognition problems using fuzzy sets".
Supervisor : Sankar Pal, ISI, Calcutta.

(B) Ph.D. degrees awarded by other Universities to the Scholars and Staff of the Institute :

(i) Joydev Chattopadhyay
"Mathematical and Stochastic Modelling of Self-organisation in biological systems with special reference to the mechanism of carcinogenesis".
Name of the University : Jadavpur University
Supervisor : P.K. Tapaswi, ISI, Calcutta.

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(ii) Asim Roy   "Topological Aspects of anomalies in quantum field theory
Name of the University : Calcutta University
Supervisor : Pratul Bandopadhyay, ISI, Calcutta.

(iii) Nabanita Das   "On the permutation capabilities, Routing and Fault -
Tolerance of some Multi stage interconnection Networks"
Name of the University : Jadavpur University
Supervisor : J. Duttagupta, ISI, and D.K. Basu,
Jadavpur University.

International Statistical Education Centre, Calcutta.

The Centre was opened in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a joint Board of Directors. 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 its inception 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, sponsored by respective Governments. Major training programme of the Centre is a ten-month regular course. In addition, special courses of varying duration are also organised. Facilities exist for research work and advanced study by senior statisticians from abroad. Since inception, the Centre has provided training to 1212 trainees from 56 countries.

A total of 39 candidates from 18 different countries were nominated by respective Governments for admission to the 47th term of the regular course of this Centre. Of these 39 candidates, 20 were offered admission and 16 participants from 6 countries joined. There were one each from Ethiopia and Maldives, two each from Bangladesh and Phillipines and three and seven from India and Srilanka respectively. Twelve trainees were supported by fellowships awarded by the Government of India under the Technical Cooperation Scheme of the Colombo Plan, Indian Technical and Economic Cooperation and Aid to Sri Lanka schemes. Among the other 4, 2 were from Indian Air Force, one each was from Tribal Sub Plan Cell, Collectorate of Daman, India and the remaining one was from Sri Lanka. All these four trainees were supported by their respective employers.

Teachers of headquarters at Calcutta of the India Statistical Institute and officers of the Government of India participated in teaching the regular courses during the year.

All the regular course trainees have been recommended for the award of the Statistical Training Diploma.

In continuation of the staff developement programme sponsored and financed by the UN Statistical Office, New York, special courses were arranged in collaboration with Indian Statistical Institute at Calcutta for two trainees. One from Mozambique for a 5-month course and the other from Botswana for two weeks. Both the trainees completed the respective courses successfully and satisfactorily.

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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 certificate and diplomas -

i) Statistical Assistantship Certificate.
ii) Junior Diploma in Statistics.
iii) Senior Diploma in Statistics.

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

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

These examinations are held now-a-days twice a year usually in or about the months of May/June and November/December at different cities in India (Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras).

The details of the examinations for June 1993 and December 1993 terms are given below :

Examinations	Number of candidates					
	Registered		Appeared		Passed*	
	June	Dec.	June	Dec.	June	Dec.
1. Statistical Assistant- ship certificate	14	16	6	9	2	3
2. Junior Diploma in Statistics	48	68	25	35	7	7
3. Senior Diploma in Statistics	10	6	2	·3	Nil	Nil

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

The total number of candidates who have qualified for the award of the Certificate and Diplomas in the Professional Examinations in Statistics including the results of December 1993 term are 484 and 265 respectively.

2. TWENTYEIGHTH CONVOCATION

Indian Statistical Institute held its Twentyeighth Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research), M.Stat., B.Stat. (Hons.) degrees and Diplomas, Associateship etc. on 11 February, 1994.

Shri P.N. Haksar, Chairman of the ISI Council, welcomed the guests and recipients of the Degrees, Diplomas, Associateships and Awards. Professor B.L.S. Prakasa Rao, FNA, Director of the Institute, presented annual review of teaching and training activities of the Institute. Professor M.G.K. Menon, FRS, President of the Institute, presided over the Convocation and awarded Degrees, Diplomas, Associateship and Awards to the students. Professor G. Rama Reddy, Chairman, University Grants Commission, New Delhi, delivered the Convocation address. In his address, Professor Reddy highlighted the interdependence of developement and higher education - a connection that seems to have been neglected for far too long.

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

Degree/Diploma/Associateship	Number of candidates
Doctor of Philosophy (Ph.D.)	11
Master of Technology (M.Tech.) in Computer Science	20
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	12
Master of Statistics (M.Stat.)	22
Bachelor of Statistics (Honours) (B.Stat. (Hons.))	22
Part-time Diploma in Statistical Quality Control and Operations Research, Madras	5
Diploma on Operation and Programming of Automatic Data Processing Equipment	5
Associateship in Documentation and Information Science, Banfgalore	7
Professional Examinations in Statistics :	
Junior Diploma in Statistics	3
Total	107

AWARDS 1993

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

    1. Kingshuk Roy Choudhury

2. Award of ISI Alumni Association Prizes to the outstanding students of the Institute :

B.Stat. (Hons.)	: Sarat Chandra Dass
M.Stat.	: Kingshuk Roy Choudhury
M.Tech. (CS)	: Palash Sarkar
M.Tech. (QROR)	: Tirthankar Dasgupta

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3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The research activities of the Institute are grouped in the following Divisions :

Theoretical Statistics and Mathematics; Applic.; Statistics, Surveys and Computing ; Physical and Earth Sciences; Biological Sciences; Social Sciences; Statistical Quality Control and Operations Research; and Library, Documentation and Information Sciences. In addition, the National Centre for Knowledge Based Computing, jointly sponsored by Department of Electronics (D.O.E.) and United Nations Development Programme (U.N.D.P.) and located in the Institute at Calcutta, has been engaged in research work under FGCS/KBCS programme. There is also a well equipped Computer and Statistical Services Centre (CSSC) which provides computing and statistical services to researchers.

A brief account of the progress of research in different Divisions and Units of the Institute during the year is indicated below :

Theoretical Statistics and Mathematics Division

The Division of Theoretical Statistics and Mathematics has Units at Calcutta, Delhi and Bangalore and Hyderabad. The Division is basically engaged in research in different areas in theoretical statistics, probability theory, stochastic processes and mathematics apart from providing theoretical support for a number of applied problems that arise in various projects undertaken by ISI and other Institutions. The Division has a major role in teaching probability, statistics and mathematics in the B.Stat.(Hons.), M.Stat., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations research) and other courses in the Institute. The Division also conducts a course for 3-4 semesters at an advanced level for Research Fellows enrolled for Ph.D. degree of the Institute. During the period under review, eight Research Fellows in statistics and mathematics, four in each, have been awarded the Junior Research Fellowships. A strong feature of the Division is to organise Summer/Winter Schools and Workshops in a variety of advanced and current topics in statistics, probability and mathematics. Besides, colloquium talks and seminar talks by faculty members and visitors are organised regularly.

The broad areas in which researches were carried out during the year are indicated below :

Calcutta Unit

Statistics

1. Bayesian Analysis, Decision Theory, Inference and Asymptotics,

Asymptotically minimax procedures, Asymptotic properties of posterior distributions, Estimation in non-regular problems, Change point problem, Bayesian generalised linear models, Generalized Cramer-Rao type integral inequalities with applications to linear models with elliptically distributed errors, Adjusted and conditional likelihood, Second order Pitman closeness and Pitman admissibility, Second order minimaxity, Admissible tests for mean of Langevin distribution, Probability matching equation for a parametric function, Numerical investigations for Polya-tree priors, Inference in social networks.

2. Sequential Analysis, Ranking and Selection, Non-parametrics

Sequential estimation of mean in NEF-DVP distributions, Likelihood based nonparametric smoothing and cross-validation techniques.

Representation theorem for U-statistics, One-sided estimates; Optimal sequential procedures in ranking and selection setup, Nonparametric estimates of conditional quantiles and their derivatives, nonparametric density estimation for associated sequences.

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3. Multivariate Analysis

Mahalanobis D^2 statistics, Asymptotic expansions for distributions of test criteria for dispersion matrix, local improvements in estimating multivariate normal mean, Robust procedures for analysing multivariate data using geometric features of data clouds, Analysis of multivariate ranked data sets.

4. Sample Surveys

Optimum estimation based on multivariate information, Finite population domains, Allocation problems in stratified sampling, Strategies for discovering new species, Multivariate surveys, Sampling methodology in social networks and anthropology.

5. Design of Experiments

Optimal computer experiments, Optimal designs for growth curve models, Use of approximate theory in exact optimality, Optimality of block designs, row column and factorial designs.

6. Applications

Applications of statistical techniques and models have been made to assignments of rotor blades in hydroturbines, lower tolerance limit for atmospheric ozone layer, wastage in paper trimming and metal cutting, etc.

Probability and Stochastic Processes

Studies on random iteration of maps are being continued. Young's theorem on limits of functions is being examined in a general framework. Progress has been made in studying the asymptotics of $(Y_t)_t \geq 0$ of the system (Y_t, X_t) where $dY_t = b(t, Y_t, X_t) dt + \sigma (t, Y_t, X_t) dW_t$. Here (X_t) is a rcll (right continuous, left limit existing) process taking values in a Polish space. Optimal asymptotic tests for composite hypotheses for continuous time stochastic processes have been obtained.

The relationship between convergence of the trajectories of a semi-martingale and boundedness, as $t \to \infty$, of the local times of the semi-martingales, has been studied.

Using an elementary approach, several classical results on the WLLN and SLLN and the related L^p-convergence problem have been extended. Convergence speed in CLT was studied under stringent conditions. Uniform approximations for families of stochastic integrals are being worked out.

Mathematics

In Descriptive Set Theory, random versions of extension theorems of Dugundji type and fixed point theorems, results on approximations and approximation selection of Caratheodory multifunctions and extensions of multifunctions, have been obtained. In continuation of research in cellular automata (CA), properties of additive 2-dim CA have been obtained for possible application in Cryptology.

Investigation of the geometric properties of H^1 and its dual BMO, both in the disc and half-plane, is still being pursued. The study of the connection between farthest points of a closed bounded convex set in a Banach space and the Mazur intersection property, has been undertaken.

In General Topology, the main preoccupation has been the study of function spaces from several points of view - topological, functional-analytic, and measure-theoretic. Attention is being specially directed to Buchwalter's bounded-open topology on the set of all real-valued continuous functions on a Tychonoff space.

In Algebraic Topology, work is in progress on (i) Fixed point theory using sheaf-theoretic methods and (ii) Equivariant cohomology of de Rham type, with applications. The work on differential topology comprises classification of equivariant immersions and symplectic and isometric immersions.

In Ergodic Theory, substitution of dynamical systems and the study of their spectra was undertaken.

In Theoretical Computer Science, study of exact/approximate algorithms for selected NP-hard problems and the question of approximability, is being continued.

In Graph Theory, topics of study include reciprocity in networks arising in social and biological sciences along with simulation and other problems, Problem of Ore on spanning trees of infinite graphs, centre and diametral graphs, perfect elimination orderings of chordal graphs and applications to discrete data analysis, self-complementary graphs, tournaments and k-trees.

A project entitled "Exploratory Generalized Regression : Function Estimation, Cross-Validation and Robustficition" was undertaken by Probal Chaudhuri and Debapriya Sengupta. A weighted maximum likelihood approach that generalizes kernal and nearest neighbourhood type smoothing techniques and a likelihood based cross-validation technique and generalize least-squares cross-validation have been developed and investigated in multiparameter and/or multiresponse set ups. Further, a likelihood based generalization of tree structured regression and recursive partitioning techniques were studied. In a different direction, nonparametric quantile regression has been used to develop parameter estimates in various survival analysis models and the monotone single index model popular in econometrics. Many useful technical results have been discovered in the course of these investigations. The project is expected to be completed in 1994-1995.

A project entitled "Affine Invariant Distribution Free Multivariate Techniques : Breakdown Point and Efficiency" was undertaken by Probal Chaudhuri, Arup Bose and Debapriya Sengupta. Some new robust procedures for analysing multidimensional observations have been developed and studied. The techniques developed exploit some critical geometric features of multivariate data clouds. Several interesting and useful results have been discovered in course of the investigation of the statistical properties and performance of these new procedures. The project is expected to be completed in 1994-1995.

A workshop on "Frontiers of Research in Finite Population Inference" was organised in the Stat-Math Unit, Calcutta, during 1-9 November 1993. Thirteen participants from various universities in the country and four local participants attended the Workshop. Recent developments in finite population inference were discussed by faculty members of the Institute as well as guest lecturers from Calcutta University and Indian Institute of Management, Calcutta. The session on the last day was dedicated to the memory of the eminent sampling expert the late Prof. M.N. Murthy, who was associated with the Institute from 1955 to 1970.

The Institute is engaged in the publication of Selected Papers of C. R. Rao. Volume III has been completed during the period under review and the book is expected to be out soon. Work on further volumes is going on and at least one more volume is expected to be brought out in 1994-'95.

Delhi Unit

Statistics and Probability

1.   Order Statistics

Recurrence relations, Duality principle, Moments of order statistics, Operator methods in order statistics.

2.   Characterization of Distributions

Characterizations based on order statistics and conditional expectations.

3.   Reliability and Survival analysis

Tests in presence of competing'risks.

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4. Design of Experiments

Optimality of designs under resource constraints; Robustness of designs against missing data; Construction of orthogonal arrays; Recovery of interblock information.

Probability

Weak convergence, Martingale theory, Percolation theory, Particle systems, Quantum stochastic processes.

Mathematics

Linear Algebra : Analysis of matrices, Path-positivity and Coxeter groups, Inequalities for permanents, Perturbation of eigenvalues and eigenvectors, Generalized inverse of matrices, Linear complementarity and Q-matrices.

1. Operator Theory

Variation of positive operators, Spectral theory, Quantum dynamical semigroups.

2. Partial Differential Equations :

Regularity of solutions of elliptic systems.

3. Game Theory and Global univalence

Jacobian conjecture.

Bangalore Unit

Research was carried out in the following areas of probability theory, statistics and mathematics :

Probability theory

Applications of large deviations to Information theory, semi-stable measures and process, diffusion processes ;

Statistics

Sample surveys, Large sample theory, Bayesian inference, Bayesian non-parametric statistics, Bayesian non-parametric estimation, Robust Bayesian analysis, Reliability theory, Optimality and construction of experimental designs ;

Mathematics

Groups of exceptional Lie type, Coxeter groups and the Monster group, Combinatorics (Bruck-Ryser type theorems for quasi-symmetric designs and strongly regular graphs), Functional Analysis, Geometry of Banach space, Ergodic theory, Operator Algebras and Operator theory, Harmonic analysis, Differential Geometry and Topology, Spectra of Laplacians (especially on Vector bundles), Spectral theory for partial differential operators, Finitely additive measures, G-inverses.

Work continued in the area of non-parametric Bayesian approach to estimating change points of a hazard rate. Asymptotic properties of the same have been investigated.

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A conditional gauge theorem for the third boundary value problem was proved. Transition densities for reflecting diffusions were constructed using a combination of parametrix method and probabilistic arguments. Asymptotic behaviour of reflecting diffusions was investigated with special reference to diffusions in half-space

and in the quadrants. Strong Feller property of semimartingale reflecting Brownian motion in an orthant was established.

Various aspects of the Pompeiu problem and the "Uncertainty principle" have been investigated. L^p-analogues of the Wiener-Tauberian theorem have been established.

Work continued on generalised Fock spaces, circle geometry and abstract interpolation. Plancherel type theorems for measures have been obtained for the case of Hermite and Laguerre expansions. A study of mean periodic functions on the reduced Heisenberg group is underway. Using a Paley-Wiener theorem for the Fourier-Weyl transformation, it is conjectured that an analogue of the fundamental theorem of mean periodic functions on the real line is possible in this set up. this had been proved in the case where the function has a tempered growth.

The problem of computing the principal graph of a subfactor obtained from a vertex model was considered. Some results have been obtained using the semi-canonical tunnel construction. Subfactor associated to a vertex model coming from a "biunitary permutation matrix" was also investigated.

The topological and geometric properties of the space of Banach space valued functions on a compact space that are continuous when the Banach space has the weak topology have been investigated. If such a space is isometric to the dual of a Banach space then it is proved that the underlying Banach space is reflexive. This along with some results of Cambern and Grein, settles a vector valued Grothendieck-Dixmier problem in this set up. Using Banach space theoretic techniques it has been proved that "all weakly continuous functions are of Baire class1" is equivalent to "any weakly compact set of scalar valued continuous functions in separable". These results improves on some work done by Srivatsa where set theoretic techniques have been employed. These ideas also lead to a more 'direct' proof of a classical theorem of Dunford, Pettis and Phillips.

A new geometric property which is useful in computing the essential norm of a operator was studied. It turns out that $c_o(\Gamma)$ is the only L^1-predual space that has this property. Some partial results were obtained on the question of complementability of the space of Bochner integrable functions in its bidual. M-structure of the space of vector valued affine continuous functions was studied and a vector valued analogue of a classical result of Bauer was obtained.

Applied Statistics, Surveys And Computing Division

The Applied Statistics, Surveys and Computing Division consists of two units i.e. Biometry Research Unit and Computer Science Unit. Faculty members of the Division were engaged in teaching and training in different courses like B.Stat (Hons), M.Stat., M. Tech. (Computer Science), M. Tech. (Quality, Reliability and Operations Research) and other courses besides research and project work. Researches carried out by these units are indicated below :

Biometry Research Unit

Biometry Research Unit is engaged in the pursuit of different Biomedical, Toxicological and Environmental problems with the generation of data in the laboratory. Research activities during the year include (i) the study of the ontogenetic development of Indian major carps including their performance in response to supplemental feeding, (ii) the genetic isozyme studies focus the variability of LDH-A and LDH-B at the early developmental states, variability of LDH-C locus indicates taxonomic distance between the species of the same family of carps, (iii) Pisciculture and growth study of the IMC seed from early stage with some supplemental food, (iv) effects of the extract of medicinal plants *Vinca rosea*, oscimum Sanctum and *Azedirachta indica* in lowering the blood sugar levels, improvement of damaged liver cells and to act as

anti-inflammatory agents in diseased experimental animals induced by drugs and a comparative study revealed that leaf extract of *Azadirachta indica* is more potent in lowering the blood sugar level and to reduce inflamation, (v) the problems of the malnutrition related young diabetes specially of *Fibrocalculus Pancreatic Diabeties* (FCPD) in the region of Eastern India.

Projects

1. Modelling Viscoelastic Properties of Blood

This is an on-going project. The influence of radiational stress on rheological properties along with simultaneous monitoring of the relevant haematological properties of rabbit blood was pursued. Significant alteration of haemoglobin content, mean corpuscular haemoglobin concentration and blood cell count was observed.

2. Development of Hypaglycemic Drugs from plant sources

In this on-going project, the crude water soluble fraction of alcoholic extract of leaves of some medicinal plants viz. *Vinca rosea*, *Oscimum sanctum*, *Azadirachta indica* revealed that these extractives are effective in lowering blood sugar level in experimental animal models. A comparative study with these extractives regarding anti-inflammatory property revealed that indica leaf extract is more potent than others. Some work on the isolated of different fraction from the water soluble portion of the alcoholic extract of these extractives with the technique of TLC is under progress.

3. An investigation into the young insulin dependent and adult non-insulin dependent malnutrition related diabetic patients

In this on-going project the recent work includes the problems of Fibrocalculous Pancreatic Diabetes (FCPD), which is a subset of malnutrition related diabetes. This study is being done for the first time in Eastern India. The data obtained by biochemical and clinical experiments indicate that most of this disease is immunogenetically predominant with HLA- DR3, DRWS3, DQW3, which is somewhat different from other workers report. Their C-peptide and plasma insulin level in blood suggest that this disease may be related to the different nutritional status of the subjects. Case study of hepatic histology on 26 patients could not give ready explanation for the greater prevalence of hepatic functional and histologic abnormalities in FCPD cases. The work in this field is new and investigation is in progress.

Computer Science Unit

The activities of the Computer Science Unit mainly consist of research in Statistical theory, methodology and applications, development of computer software for Statistical purposes, providing statistical consultancy and services to individual researchers in various fields and organisations, conducting studies on topics of national interest requiring statistical techniques. The expertise of the unit is in a constant demand by Government departments and Organisations in the public sector. A brief account of research activities during the period is given below :

1. Sample Surveys.

Fruitful theoretical research is continuing around optimal estimation of finite population mean and variance under errors-in-variables superpopulation models and estimation of population totals and variances under various models-such as, controlled sampling, randomized response surveys and small Domain estimation. The nearest proportional to size sampling design and its application to controlled sampling is receiving special attention.

2. Design of Experiments.

Successful research findings relate to (i) construction of symmetric Balanced Squares, nearly balanced uniform repeated measurements (ii) optimal repeated measurements designs under mixed effects models.

3. Multivariate Analysis, Directional data analysis and Reliability Inference.

Research areas of special attention cover (i) selection of the t-best cells in multinomial distribution, (ii) studies of symptotic estimation problem for a large class of multiparameter discontinuous desities in obtaining asymptotic behavior of the maximum likelihood estimator, Bayes estimators and posterior distributions, (iii) asymptotic estimation problem for multiparameter families of denseties with singularity w. r. t. one parameter, (iv) an expansion of Bays' risk w. r. t. entropy loss has been obtained for a family of discontinuous densities with a single parameter and used to obtain a reference prior in the sense of Bernardo, (v) Derivation of optimal invariant test in possibly non-regular mixture families, (vi) characterisations and semiparametric inference related to Cox's Discrimination rules, (vii) Tests for change-point and uniformity in Directional data problems, (viii) optimal tests for independence in Bivariate exponential distributions, (ix) Reliability bounds for the L-class and Laplace order, and (x) monoforacily of some tests in the Langivin distribution.

4. Regression Analysis.

Important works in this area cover (i) recursive inference in the general linear model, (ii) a computationally robust and promising alternative to the ridge estimator in the context of collinearity in regression. Some significant contributions in the areas of survival analysis, signal processing and cellular automa are (i) testing the hypothesis of proportional hazards in two populations, (ii) testing the proportionality of hazards due to competing risks, (iii) estimation strategies for the arrival angle of multiple signals from observations made by an array of sensors, (iv) cellular automata based VLSI architecture for computing multiplication and inverses in $GF(2^m)$.

Projects

1.   An Empirical Investigation of Effectiveness of Emerging Small Domain Estimation Procedure compared to Traditional Methods in the Indian Context

This is an on-going project. As the plan is to examine the performances of the procedures based on Indian data some live data of size 200 from ISI accounts office have been collected. Various units (say domains) of ISI are of varying sizes. So the traditional methods of sampling strategies for estimating domain total are not found effective for those of very small sizes. A newly emerging model-based estimators are tried to examine if efficiencies may be improved. Necessary data have been gathered from the ISI Accounts office. On the basis of the findings a Technical Report has been prepared.

2. Study On Rural Indebtedness In West Bengal

This is a new project. The NSSO conducts All India Debt and Investment Survey (AIDIS) every 10th year and the latest survey was conducted in 1991-92, the result of which is still awaited. The result based on earlier survey indicated a steep decline in the incidence of indebtedness. This led to wide debate since such decline was contrary to the general expectation, specially when the banking network penetrated in deep rural areas.

The main aim of this project is to make a comprehensive study of data supplied by institutional sectors and data to be collected from household surveys. The proposed area of coverage is few blocks from 2-3 districts of West Bengal.

During the year, ground work for the survey has been done. Contact has been made with Reserve Bank of India, Planning and Development Dept. Govt. of West Bengal and NSSO. For conducting the survey two districts of West Bengal have been chosen purposively — Hoogly (near Calcutta) and Murshidabad (away from Calcutta) and 4 blocks have been selected from each district using Rao-Hartley-Cochran scheme, the size measure being the 1991 census population of the blocks. The sampling frame has been constructed and also the sampling is completed. The schedule for the household survey has been prepared and printed. The household survey is scheduled to start from March 1994.

3. Generalized Linear Model

This is an on-going project. A partial survey of the literature on collinearity diagnostics has been made. An alternative to ridge regression estimator has been considered. A comparison of this estimator with ridge estimator is made from the computational point of view. A number of advantages has been found in favour of the proposed estimator. A study of the estimator from the point of view of condition number is also made and some optimal properties of this computational scheme are established. The variance decomposition proportions

method of detection of collinear relationships among regressors seems to have some drawbacks. An alternative procedure is proposed and detailed study using live data sets and simulations is in progress.

Externally Funded Project (CSU)

1. Socio-economic Survey of the Sericulturist

There are five States in India (Karnataka, Andhra Pradesh, Tamilnadu, West Bengal and Jammu and Kashmir) traditionally producing mulberry silk. Apart from these the Central Silk Board (CSB) is trying to extend silk farming in other 12 States of India under its National Sericulture project.

The CBS, Bangalore of the Ministry of Textiles, Government of India had pended a project on Socio-economic Survey of the Seri-culturists and non-sericulturists in West Bengal. Computer Science unit had undertaken this project. The objective of the project was to estimate total acreage under mulberry, total production of cocoon and silk yarn in West Bengal. It was also projected that the survey would through up estimates of income generated from sericulture and highlight its importance in relation to other productive activities. It was also planned to estimate family labour participation, in particular the female labour in sericulture. The project has been completed during this year.

The project leader delivered the following invited talks. (i) 'On Micro-Level planning' – at the Administrative Training Institute, Calcutta, Government of West Bengal in an In-service Training on Decentralised District planning on June 16, 1993. (ii) On Data Requirement for preparation of Microlevel Plans' – at the State Institute of Rural Development, Kalyani, Nadia, West Bengal in a Training of Trainers' course on Decentralized planning, conducted by the National Institute of Rural Development, Hyderabad on Dec. 8, 1993.

Physical and Earth Sciences Division

The Division comprises the Chemistry Unit, the Electronics Unit, the Electronics and Communication Sciences Unit, the Geological Studies Unit and the Physics and Applied Mathematics Unit. Faculty members of the Division are engaged in teaching and training, besides research and project work. Researches carried out in these units are described below :

Chemistry Unit

Research activities of the unit during this period was carried out through the following approved projects.

1)   Distribution and Characteristics of Allophanes in West Bengal soils.

Soil profiles from sub-Himalayan and lateritic regions of the state were critically examined for the presence of allophanes in the clay fractions of all) the horizons. It has been established mainly by IR-Spectroscopic method that considerable quantities of allophane exist on both the soils and their abundance increases with depth. This explains the accumulation of appreciable quantity of organic matter in the sub-surface region. Allophanes are found to bind organic matter strongly.

2)   Absorption at solid-solution interface

Intake of pesticides and structurally related materials by whole soil and soil separates have been investigated. Cationic and amphoteric pesticides have been found to be strongly absorbed. Surfactants favour the absorption probably through dispersion effect. Study of the desorption, mobility with irrigation water and persistence were also undertaken but remains to be completed.

This work is of utmost importance in soil environmental studies.

Electronics Unit

The faculty members of the Electronics Unit are currently engaged in teaching, research and developmental work in the field of Computer Science. Details of these activities are described below.

The Unit shared a large portion of the teaching load in the M. Tech. (Computer Science) programme of the Institute. Also, the dissertation works of a number of M. Tech. (Computer Science) students of the Institute have been and are being supervised by the faculty members of the Unit every year. In addition, quite a large number of students from IIT's and other Universities visit the Unit for their vocational training.

Faculty members of the Unit were engaged in supervising the Ph. D. works of 5 I.S.I. scholars and 11 outside scholars from different Universities and Institutions. One research scholar and another staff member of the Unit submitted their Ph.D. dissertations during the period.

The research areas persued by the members of the Unit included Parallel Algorithms and Parallel Architectures, Network Topology, Interconnection Networks, VLSI Layout Design, Logic Synthesis and design for testability, and Computational Geometry.

1. Parallel Algorithms and Parallel Architectures

The objective of research in this area includes the following :

i) Design of efficient parallel algorithms for various numeric, non-numeric and graph-theoretic problems, problems on computational geometry; mapping these algorithms on suitable parallel architectures.

ii) Design of fault-tolerant parallel architectures for different numeric and non-numeric problems.

iii) Testing and design for testability of systolic arrays.

New parallel algorithms for fast multiplication in redundant quarternary number systems, Lagrange's interpolation with i) $O(\log n)$ time and $O(n^2)$ processors and ii) $O(n/\log n)$ time and $O(n \log n)$ processors, solution of polynomial equations, power series manipulations have been developed during the period 1993-94.

2. Network Topology

The objective of this study is to substitute topologies for computer networks in order to have a network with small diameter, low number of communication links, incremental extensibility, fault-tolerance and ease of routing in both fault-free and faulty situations. Many of these requirements are mutually conflicting in nature. An optimal design is still called for.

A new network topology called Multimesh (MM) network has been proposed. This network uses small 2-D meshes as the basic building blocks, which are interconnected in a suitable manner. The proposed topology is 4-regular with a diameter of $2n$ for n^4 processors. Algorithms for various applications have been efficiently mapped on this architecture.

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A new network topology which exploits the ideas present in Cube-Connected-Cycles and Generalized Hypercubes, has been introduced. This network is (l+1)-regular with a diameter of 2.5m for l^m number of nodes. Connectivity of this network is 1. The diameter increases only by 2 for a maximum of 1 faults in the network. Various algorithms have been efficiently mapped on this architecture.

Another new network topology with average node degree of 3 and diameter of 1.5m, where m is the least number satisfying the inequality $N \leq 2m.2^{m-1}$, N being the total number of nodes, has also been found out. Mapping of algorithms on this network and reliability analysis of this network are being studied.

Optimal communication algorithms for double loop networks have been developed.

A family of generalized odd-degree dense graphs have been introduced.

Another new network architecture with the maximum node degree of 3 has been proposed. This network uses trees as the basic building blocks which are interconnected in a suitable manner. Algorithms for bitonic sort and DFT have been efficiently mapped on this architecture.

3. Interconnection Networks

A general class of rearrangeable interconnection networks have been defined. Different self-routing algorithms have been developed for these networks to route different classes of permutations. New group transformation rules have been proposed for rearrangeable networks that enable us to route a large class of permutations in O(log N) time in an N x N rearrangeable network. Some fault-tolerance properties of this class of rearrangeable networks have been studied and specific fault-tolerant routing algorithms have been developed for routing permutations in presence of typical classes of faults.

Multi-layered design of strictly non-blocking Benes and shuffle-exchange networks have been completed. Variations of this multi-layered design approach with m x n switches (m, n > 2) are currently under study.

Fault-models for detecting and diagnosing short-circuit faults in Benes network as well as Clos network have been developed. Test vectors for locating these faults have also been designed.

4. VLSI Layout Design - Phase II

The objective of this project is to develop algorithms for efficient design of VLSI layout. We consider the graph dualization method of floorplanning. Given a topological neighborhood graph, a heuristic search technique based on AND-OR graphs has been investigated and implemented. The proposed algorithm produces optimal solutions on almost all standard benchmarks. It also recognizes inherently non-slicing floorplans very quickly. We also studied various transformation techniques for converting non-slicing floorplans to slicings. This would greatly help the placement and routing in the later phases of chip design.

Another area of investigation includes the study of various new routing models. New algorithms based on overlap-diagonal model have been proposed. Elegant and fast solutions have been obtained for difficult benchmarks using this model, e.g., Deutsch difficult example, cycle.tough, Burstein's channel and switchbox. We also explored various AI-based techniques for channel routing, and obtained very significant results in terms of execution time, cost of solutions etc.

5. Applications of Computational Geometry to VLSI Layout Design

We identified many new design problems that arise in VLSI physical design automation, and mapped them to computational geometric problems. New algorithms for maximum-empty-region recognition among isothetic/non-isothetic obstacles are proposed. This includes recognition of max-width / area staircase channels, 3D cuboids etc. We also introduced a new class of stabbing problems called "optimal firing". These problems have manifold applications to defense, VLSI, robotics, database and pattern recognition.

6. Logic Synthesis and Design-for-Testability

Isomorphic redundancy in sequential logic circuit is a mysterious property and whether or not there exists a real circuit that exhibits this kind of redundancy remained an open problem for a long time. We have studied this problem in detail and found a series of examples of such circuits and their underlying properties. Currently we are working on their identification and removal.

Delay-fault testing is another area of current interest, and we have developed a design-for-testability technique for constructing 100% delay-fault testable combinational circuit. Our results outperform existing techniques in simplicity and cost-effectiveness.

7. Design of Reconfigurable Fault-Tolerant Array Processors/Systolic Arrays

This is a research as well as a developmental project. The major goals of this project are as follows :

i) Studies and subsequent design of reconfigurable, fault - tolerant parallel architectures constructed by interconnecting processors ;

ii) To develop algorithms for reconfigurability and routing in presence of faults in different parallel processing environments, e.g., hypercube, cube-connected cycles, mesh, de Bruijn network, etc. ;

iii) Studies on algorithmic fault tolerance in the context of parallel processing ;

iv) Studies on design for testability of unilateral/bilateral 1-dimensional /2-dimensional systolic arrays and their implementations ;

We have studied models of 1-D bilateral systolic arrays and developed new techniques for their testing. The problems of fault-tolerance, reconfigurability and design for reduced diameters in hypercube architectures have been completed.

During this period, 11 papers have been published in leading International Journals and International & National Conference Proceedings, 7 papers have been accepted for publication in International Journals, 3 papers have been accepted for publication in conference proceedings, one article has been published in book and 14 papers have been communicated to different international journals of repute. Faculty members of the Unit were actively associated with organizing one International conference on VLSI design and another national seminar on Theoretical Computer Science. Seven distinguished scholars visited the Unit and delivered seminars besides collaborating with the faculty.

Electronics and Communication Sciences Unit

Apart from regular research activities, faculty members of the Unit regularly participated in teaching and training in M Stat., M.Tech, (Computer Science). M. Tech (Quality, Reliability and Operation Research Courses) of the Institute. They also were engaged in supervision of Ph D work Many under graduate/post graduate students of Computer Science, Electronics and Telecommunication, Electrical Engineering, Master of Computer Application Courses from different Universities underwent their vocational semestral training under the supervision of the faculty members of the Unit Also, a staff member submitted his Ph.D. thesis during this period

1.   Studies in Pattern Recognition, Pattern Classification and Learning Algorithms

i)   An Optical Character Reader (OCR) system has been designed for machine reading of "Bangla" printed script. The accuracy level of the OCR is quite high. Work is in progress for further development of the system. One goal in this context is development of reading aid for the blind

ii) Work on analysis of biomedical images using texural features has started in collaboration with scientists in GSF, Munich.

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iii) Work on classification of satellite images into physical classes (like water, vegetation, man-made structures) is continuing. A new perceptron based neural network classifier has been developed for classification of multispectral image data.

iv) Studies on data clustering, dot pattern shape analysis and probability density estimation are continuing. Algorithms for seed point detection have been developed and a new definition of neighbourhood is proposed that leads to a set of symmetrical neighbours of a point.

2. Studies in Image Analysis and Texture Analysis

i) Work on mathematical morphology, a powerful tool for image processing and analysis, is continuing. Past algorithms for basic mathematical morphological operations on sequential machines have been developed and their computational complexity studied. These operations have successfully been applied to PCB inspection and object recognition problems. They have also been used in the study of geometrical and topological properties like connectivity, convexity, Euler number etc. of image objects.

ii) Work is in progress for automatic texture segmentation using Fractal Geometry. An efficient method of computing Fractal Dimension has been published. Taxonomical classification of texture is also continuing. A technique for finding directional texture has been developed and tested. Texture synthesis work based on neural network and other tools is in progress.

iii) An interesting characterization of 3D digital topology is reported. An efficient approach to computing Euler number has been developed. A topology preserving 3D thinning algorithm has been proposed. Also, segmentation of 3D skeleton using topological information has been studied.

iv) An efficient algorithm for segmentation and linking of linear structures like roads, small rivers that may be present in gray level images, has been developed. It has been tested on IRS (Indian Remote-sensing Satellite) images with satisfactory results. The algorithm is now being modified for application on SPOT (French Satellite) images which have a different resolution from IRS images.

v) A Robust and Parallel Thinning Algorithm (RAPTA) for binary images has been developed and reported. It is quite efficient in terms of both speed and accuracy.

3. Signal Processing, Microwave Propagation, Atmospheric Studies with Appropriate Application

(i) In-depth study of beyond-the-horizon microwave signal propagation and their characteristic analysis is being continued. The T.V. Signal transmitted from Khulna Bangladesh 150 Km away from ISI, Calcutta has been received for analytic studies purposes. Simultaneously LOS signal transmitted from Satknin, Bangladesh has also been considered for performance analysis along with the meteorological/climatological condition prevailing in lower atmosphere at that period of observation. One paper containing these results is being accepted in IJP and two others papers have been published in Int. conferences at Japan & India. Same observational studies on Railways Link (at Sealdah and Khana) are being continued.

(ii) Computer analysis using image processing and pattern recognition techniques have been applied in the large volume of sodar data for the analysis/modelling of lower atmospheric structures. Successful application of these techniques resulted in noise free ABL structures to ensure indepth studies of them. On these aspects one paper has been published in IJRSP, two papers have been accepted in int. journals and one paper has been published in Int. Conf. Proceeding. On the modelling aspects one paper has been accepted in Int. journal and one published in Int. Conf. Proceeding.

(iii) Laboratory experimentation on Laser system has been continued. For details study between Geology Building - Library Building and also Library Building and INRAPHEL, Calcutta University some accessories like power amplifier & PMT are being needed and also processed for their purchasing. Full fledged operation will be started on getting those in 1994.

Research carried out in microwave propagation either in line-of-sight or beyond-the-horizon mode will be utilised in designing microwave link system, to study the fading rate and depth and attenuation

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characteristics. In conjunction with atmospheric studies in the lower atmosphere will give the probable causes and their sources for the anamolous propagation. In atmospheric field of studies the computer analysis (using IP/PR) in conjunction with meteorological climatological information would resulted in an expert system for the prediction-recognition of ABL structures and their dynamics.

4.   Speech and Music

The acoustic analysis of non nasal vowels and nasal consonants have been completed. The spectral characteristics of fricative consonants have been reported in conference. Acoustic phonetic study of vowel formants in Assamese language has been completed. Identification of fricative consonants on the basis of an glide vowel formant transition has been communicated to international journal for publication. Perception experiment has been conducted to investigate the minimum duration required for identification of fricatives. One experiment performed here strike at the root of old accepted conviction of perception of vowel category through formant structures.

Dialogue has been designed and synthesis routines worked out to develop a system for reservation and enquiry using speech Mode Interaction (RESMI). Work also has been done on speaker independent large vocabulary isolated word recognition system.

In the area of speech synthesis, Bengali and Hindi speech sounds in word form and continuous sentence form have been generated. Work on introducing intonation is in progress.

In the area of music research, procedure and software for synthesis of singing has been developed using purely time domain approach. This attracted international attention. The unit was included in an exclusive international singing synthesis group consisting of four other distributions abroad. The group is further invited to present an vocal ensemble with the other members of the group in SMAC'93, a ten yearly International Conference in Music.

5.   Artificial Intelligence and Fuzzy Sets

i)   Natural Language Processing : A computer in plementation motivated morphological and syntactic formalism for Indian Languages (Bangla or Bengali in particular) has been proposed. An object-oriented implementation platform designed and partially implemented. Also, problem related to anaphora resolution and other ambiguity analysis are being studied. Work for development of Bangla spell checker is in progress.

ii)   Approximate Reasoning : An alternative approach to fuzzy reasoning has been proposed. With the concept of likeness of fuzzy sets, a mathematical model has been formulated for approximate reasoning using truth-qualified vague predicates.

6.   Artificial Neural Networks

i)   Work on the speed and accuracy of the ANN learning algorithms is in progress. If the gain term during learning is made adaptive, learning algorithms converge faster. Another problem that involves getting stuck at a local minimum on the error surface during learning is also being studied.

ii)   Investigation into application of neural networks in computer vision has started. A dynamic neural network has been developed for computing an efficient shape representation of simple objects in 2 dimensions. Also, Hopfield neural networks are being used for texture generation.

The International conference organised as a part of the Birth Centenary Celebrations of Professor P.C. Mahalanobis, FRS, a pioneer of Indian statistical research, was held at the Indian Statistical Institute, Calcutta. The inaugural session of the conference was presided over by the famous physicist Professor M.G.K. Menon, FRS, President of Indian Statistical Institute and former Minister of Science and Technology of the Government of India. The conference was truly international in character with 40 registered participants from North America, Europe and Japan, and as expected there were more than 100 Indian participants. Total number of papers presented were 81, out of which 17 were invited papers. There were 20 sessions in 4 days on different topics.

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Professor J.K. Agarwal, President IAPR, in his inaugural address stressed on the life and contributions of P.C. Mahalanobis in diverse areas, such as Anthropometry, Psychometry, Agricultural Science, Sample Survey, National Planning and Statistical Classificatory analysis, including Mahalanobis's Distance Function. Active participation by the President of IAPR was very much appreciated by the Indian participants.

One of the significant features of this conference seem to be the indication of a new area of applications of PR and IP in the fields of atmospheric and environmental sciences. This was amply indicated in his address of Chief Guest by Professor A.P. Mitra, FRS, former Director General of CSIR and also in the invited talk by Professor R. Narasimhan, FRS, Director of National Aeronautics Laboratory of India. There were about 15 contributed papers in this broad field.

Professor D. Dutta Majumder in his plenary lecture entitled "Mindbody Duality : Its impact on Pattern Recognition and Computer Vision research "presented a review of western and eastern views on this controversial issue.

Professor A.K. Joshi of the University of Pennsylvania, USA presented an invited lecture on recent trends in natural language processing which was extremely useful in the context of NLP problems in a multilingual environment in India. The papers on Indian classical music and musical instruments were another significant features in this conference.

Externally Funded Projects

1.   Procedures for Spectral characterization

The goal of the project is spectral characterization of objects of defence interest on the basis of satellite imagery.

2.   Data Compression and Automatic Feature Extraction from remotely sensed data and topographic maps.

The main activities of the project are to find algorithms for (1) satellite data compression (2) automatic feature extraction from remotely sensed data and topographic maps. Geometric shaped object recognition is also considered. Scientists from ADRIN visited ISI and were satisfied with the progress of the project.

3.   Studies of the Tropical Boundary Layer Meteorology at Banaras using sodar and tower data (National MONTBLEX Program)

This project has been completed (1990-1993). Final report is being completed. Part reports were already discussed in the DST) (AS) conferences and published in the respective proceedings.

4.   Computer Application for Recognition & Interpretation of Acoustic Radar Imageries.

This is an ongoing project started in January 1994.

5.   Studies on PBL Dynamics using sodar & tower data at BHU, Banaras & ISI, Calcutta and to predict Scallar Transport Phenomena.

This project is in continuation of earlier STBLM project (1990-93) and started during December 1993. Some analysis work is being carried out in-continum to earlier project. Tower data/satellite data has to be procured and project personnel to be employed.

Geological Studies Unit ·

During 1993-94, the unit took part in the teaching of B.Stat.(Hons.) course of the Institute and Ph.D. supervision. Some members also took part in the teaching of other units on invitation. A senior research fellow of the Institute also submitted the Ph.D. dissertation during the period.

Research was undertaken in the following areas during the period :

A. Structure, tectonics and stratigraphy or precambrians

(i) Tectonostratigraphic studies of the Delhi Supergroup, its relation to the adjoining BGC, near Kharwa, Central Rajasthan.

(ii) Cover deformation in the Cuddapah basin.

(iii) Structural constraint relating tectono-thermal events to Charkonite formation in the amphibolites to granulite transition zone in south Karnataka.

(iv) Stratigraphy and sedimentation of the proterozoic sedimentaries in the eastern part of the Chattisgarh basin, with special reference to sedimentary dynamics, basin tectonics and evolution of the carbonate platforms.

B. Paleontology and stratigraphy of Gondwanas

(i) Study of the crocodilian remains from the Kota Formation of the Pranhita-Godavari Valley.

(ii) Fossil amphibians from the Denwa Formation of the Satpura Gondwana basin and their bearing on the stratigraphic relationship with the Maleri Formation.

(iii) Dinosaur remains from the Infra-Trappean (=Lameta) sediments at Piadura and Dongargaon in the Wardha Valley.

(iv) Stratigraphy, fossil and geological relationship of the Lameta Beds of Jabalpur, with special emphasis on terminal cretaceous extinction.

(v) Stratigraphy and sedimentation of the Lower Gondwana of the Satpura basin, Madhya Pradesh.

C. Quantitative Geology

Influence of impurity phase on quartz c-axis orientation development.

The important developments in the research activities of the unit are :

1. *Cover Deformation in Cuddapah Basin*

Field geologic data obtained from the east of Cuddapah (Kanomalopalle - Bakharpet - Vontimitta section) and comparison of the section with the structure section at Diguvametta - Nandi ka Nama Pass traverse indicate that there is a longitudinal variation in the deformation style along with western margin of the Nallamalai fold belt. West verging imbricate thrusts are common in the northwest of Kanomalopalle R.S. Large transverse faults (E-W trend) influence the facies distribution within the Nallamalai Group outcrops and these were reactivated during the evolution of the Nallamalai fold-thrust belt. Reorientation of the early formed folds and cleavage along the transverse fault zones is common.

2. *Structural constraints in the amphibolites to granullite transition zone in south Karnataka*

Field work, supported by lab studies, indicates that the in situ charnockites are reborn from the basic granullites, and these are unrelated to the Peninsular Gneiss. The Peninsular gneiss is also inhomogeneous; only the melanosomes are of tonalitic composition, comparable to the charnockites chemically.

3. *Proterozoic stratigraphy and sedimentation in the eastern part of Chattisgarh basin*

Mapping of about 500 sq km. of the Proterozoic Chattisgarh sequence around Sarangarh, Madhya Pradesh suggests a shallow water as well as a deep water assemblage; the latter appears to have been thrusted

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up on the former. The shallow water assemblage represents a thick fan delta sequence, comprising of wave/tide influenced shallow marine sandstones with intercalated pyroclastics. The deep water assemblage consists of thick pyroclastic deposits, red shale and lithographic limestones of shelf - slope affinity. The work, for the first time, records the presence of a thick deep water sequence dominated by pyroclastics in a basin that appears to be tectonically more disturbed than what was envisaged.

4. *Gondwana stratigraphy, palaeontology and sedimentation*

The research activities include study of lower Jurassic crocodilian remains from the Kota Formation which is likely to provide vital information about the osteological details of the Kota crocodile skull along with its phylogeny and ecology, not available till now.

Another project involves study of dinosaur remains from the Infratrappean sediments at Pisdura and Dongargaon in Wardha Valley, Central India. It reexamines the type material obtained from the area to evaluate the taxonomic status of the dinosaurs (nearly 65+ million years old) and to correlate them with similar faunas obtained at other places in India.

An exploration for vertebrate fossils from the Motur Formation of the Lower Gondwana sequence of the Satpura basic had been carried out. The work has a considerable stratigraphic significance since no fossil has so far been obtained from the same formation. A mapping of the lower Gondwana sequence of the basin is underway.

The stratigraphic field work that involves the Upper Gondwana Pachmarhi, Denwa and Bagra Formations in the Satpura basin has resulted in the delineation of the Bagra and the Denwa Formations, a problematic subject till now. A major revision and modification of the earlier stratigraphic set up for the Triassic Gondwana of the Satpura basin is almost complete.

Important and very well preserved fossil amphibians have been discovered from the Denwa Formation.

The stratigraphic work in and around Jabalpur has resulted in a major revision of the previous stratigraphic set up of the mesozoic sedimentary rocks exposed there. The Jabalpur and the Lameta Formations have been redefined and a conformable interrelationship has been established. Besides, the sedimentary history of the two Formations, one (Lameta) lying above the other (Jabalpur), has been worked out. It suggests that both are the products of the same fluviatile process(es) acting on the surface of the earth at Jabalpur at the Upper Cretaceous time.

5. Quantitative Geology and Computer Applications

CPO in Quartz, influence of impurity phase

New quantitative measurements on quartz-c-axes demonstrate that the quartz tectonites (mylonites) from the Singhbhum Shear Zone have a type-I cross girdle pattern whose asymmetry is consistent with a kinematic movement of hanging wall (Chaibasa Formation rocks) towards south over Dhanjori Group. Some additional mylonite zones, mapped in footwall quartzites (Dhanjori Group) also show a similar CPO (c-axis preferred orientation) suggesting a number of north dipping thrusts below the classical Copper Belt Thrust (the zone with Cu-U-Fe mineralization) in the sector Royam and Rohinbera, Singhbhum district.

CPO in a number quartzites with mica proportion varying between (1% - 15%) have been further analysed using orientation tensor matrix (OTM) calculation and eigenvalue ratios of OTM. There appears to be an empirical negative correlation between mica content and fabric intensity estimated by eigenvalue ratio.

A two-dimensional cephalometric study of Triassic Temnospondyls (amphibian) has been conducted. It is expected to be helpful to palaeontologists, particularly interested in temnospondyls. The work, which has been recently published, includes variation in shape of the skulls and minor variations within the skulls in a 'population'. Some special characters showing important shape changes and some aspects of functional morphologies have been considered. Factor analysis performed on some measured distances between

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landmarks of 'metoposaurid', a temnospondyle, skull has brought out important shape variabilities within a family.

Soil Chemistry

Electron transfer is important in any field of chemical aspects. Absorption and fluorescence spectra of TCNQ (acceptor) in presence of hexylamin (HA, donor) has been measured in apolar, micellar and W/O microemulsions media stabilised by AOT. TCNQ forms 1 : 1 change-transfer complex with HA in all media and quenching by amine itself has been observed. The CT-complex is characterised by Bensi-Hildebrand and Stern-Volmer equations, and preferable location of the complex has also been ascertained. A method for measuring critical micelle concentration (CMC) in apolar media has been developed from the study of flurescene quenching.

K. Dasgupta, SRF, has submitted her Ph. D. thesis titled "New Reptiles (Diapsida : Archosauromorpha) from the Triassic Yerrapalli Formation, Deccan India : their importance in Geology and Palaeontology" to the Calcutta University in December 1993. Her supervisor is Professor T.K. Roy Chowdhury.

Externally Funded Project

The Unit has undertaken a project entitled "Structure, metamorphism, anatexis and magmatism across the northern boundary of the Eastern Ghats mobile belt around Bengal and Orissa". The leader of the project is Samarendra Bhattacharya and the project is funded by the Department of Science and Technology, Govt. of India.

Machine Intelligence Unit

This unit was formed on 30 March, 1993. The main research areas of the unit include Pattern Recognition, Image Processing, Computer Vision, Fuzzy Sets, Neural networks, Genetic algorithms, Fractals, Approximate reasoning and Uncertainty analysis.

The academic activities of the unit from April '93 to January '94 are furnished below.

The faculty members of MIU are engaged in teaching and training in M. Stat and M. Tech (Computer Science) courses of ISI. They are also engaged in the supervision of M. Tech projects/dissertations besides the supervision of Ph.D. works. Many students from different universities undergo their vocational/semestral training under the supervision of the faculty members of MIU. Two research scholars and one research associate received their Ph.D. degrees during the period.

During the period under report, research activities were carried out in the following areas with satisfactory progress.

1.   Pattern Recognition

Algorithms have been developed for determining multiclass (fuzzy) boundary and shape of a pattern class in both R^2 and R^n from its sampled prototypes. This reduces and/or represents the uncertainties involved in the conventional crisp procedures. A multivalued recognition system has also been developed. Its theoretical performance (including the convergence properties) has been established. Successful implementation of this system in identifying ill-defined man-made objects such as airports, seaports, road maps and beaches has been demonstrated on IRS image data.

A new concept of generalized guard zone (GGA) has been formulated for discarding unreliable patterns for parameter learning. Its convergence and selection of optimal guard zone have been established. Some applications on real life data have also been demonstrated.

A minimal spanning tree based criterion for the selection of seed points has been proposed and its utility has been demonstrated on various data sets. A density estimation procedure, which uses Parzen's results, has also been developed in this regard. This estimation procedure has been found to give satisfactory results on artificial as well as real life data sets.

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A split and merge clustering technique and a metric for higher dimensional data sets have also been developed. A modification in k-means algorithm has been suggested for reducing the the no. of computations. A minimal spanning tree based criterion for finding *alpha* for the construction of *alpha* hull has been found.

2.   Image Analysis/Processing and Computer Vision

New definition of classical entropy based on exponential behavior of gain, and the definitions of various image entropies have been introduced along with their properties. The image entropy measures include local, conditional, positional, hybrid and higher order fuzzy entropy. These information measures take care of the dependency of pixel intensities, probability and possibility distributions of pixel, collective pixel property and location of an object in the scene. Various algorithms for image segmentation, quantitative scene analysis and robot vision problems have been developed using these measures. Mathematical theory of fuzzy image thresholding has also been developed.

Techniques for data compression of binary contour images as well as extraction of contours from gray images have been developed. Preprocessing part of the low cost parallel mode algorithms for image processing and analysis of finger print data (using graph theoretic technique) have also been completed.

A new smoothing algorithm for digital images using isotropic and anisotropic diffusion processes has been developed. Data compression of binary contour images using discrete circular geometry is now under investigation. Its merit over other conventional techniques also
being studied.

3. Artificial Neural Networks

Principles of neural computing have been successfully employed in Pattern Recognition, Image Processing and Computer Vision fields.

Neural networks (NN) have been used to find the maximum-a-posterior probability (MAP) estimate of a scene modeled as a Gibb's random field. The MAP estimation problem which is computationally prohibitive has been solved using a modified version of Hopfield's neural networks. Relaxation type algorithms for object extraction have been developed which optimize objective functions that can be mapped as the energy function of a Hopfield-type network Kohonen's model of self-organizing feature map has been modified to solve object extraction problems. The algorithms work well in noisy environments. A mathematical model for investigating the robustness of neural network based systems under component failure has also been developed in this context.

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are proposed. The principle of the model has been used to build a psychologically motivated connectionist system for learning and simultaneous recognition of multiple objects (PsyCOP). Application of Hopfield model has been studied for graphical matching of different structures. The cooperative and competitive properties of neural networks are also exploited to link different edge and line segments. A connectionist system for learning and recognition of linear structures and its application to handwritten character recognition has been developed. Principle of Hough transform is used in this development. Presently, the effectiveness of neural networks is being studied for skeletonization in greylevel images. Some efficient algorithms based on cellular neural networks have also been developed for object extraction problem.

The generalizations of Kohonen's LVQ model have been proposed and used in clustering and image processing problems. In this context, relations between LVQ and various c-means type algorithms are established.

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4. Fuzzy Logic and Uncertainty Analysis

Various fuzzy set theoretic operators are developed for soft data analysis These include index of area coverage (IOAC), fuzzy medial axis transformation (FMAT), bounds for membership functions, divergence between fuzzy sets and spectral fuzzy sets. The bound functions and spectral fuzzy sets enable to reduce the uncertainties in assessing membership value and to make the fuzzy set theoretic approach enough flexible. FMAT is useful for both skeleton extraction and exact reconstruction/representation of images without committing ourselves to a specific hard thresholding. The divergence measure between two fuzzy sets provides an amount of discrimination between them and has been successfully utilized in image segmentation problem.

Based on approximate reasoning, a linguistic recognition system has been formulated and tested with real life data. This has been found capable of handling various imprecise/uncertain input patterns and provides a natural decision system.

A new measure of total uncertainty for Dempster-Shafer framework has been suggested. This new measure takes care of uncertainty due to non-specification
and randomness and is free from several drawbacks of earlier attempts. Properties of iterates of fuzzy circulant matrices under max-min operations have been investigated. A shape estimation procedure has been developed with the help of fuzzy *alpha* hulls.

5. Neuro-Fuzzy Processing

Attempts have been made to integrate the merits of fuzzy logic and artificial neural networks for designing an efficient decision making system. Concept of fuzzy sets has been incorporated at various stages (e.g., input, output, learning and neuronal level) of Kohonen's network and multi-layered perceptron to handle imprecise, incomplete or linguistic input data and intractable pattern classes for recognition. Its extension to connectionist expert system for rule generation and inferencing has been made along with applications to real life data. This shows how pattern description in terms of linguistic properties and membership values can be processed by a neural net for fuzzy and crisp classification, and their merits over conventional networks and Bayes' classifier. Utility of such architectures for generating non-convex decision regions is also demonstrated. A generalized framework for integration of multilayer perceptron and fuzziness measures has been developed to design an unsupervised system for object extraction. Implementation of fuzzy set theoretic operators using neural networks and the utility of these networks in pattern classification and rule generation have been demonstrated.

6. Genetic Algorithms and Fractals

Genetic algorithms - which are adaptive, parallel and robust search techniques - have been used in Pattern Recognition and Image Processing problems. Their applications in the automatic selection of optimal image enhancement operators have been established successfully. The selection of optimal parameter values of multilayer perceptrons and cellular networks has also been made. It relieves multilayer perceptron from using back propagation technique. A new mutation method called (\em directed mutation) is developed which accelerates the rate of convergence of the genetic algorithm to a great extent. Efforts are being made to prove the convergence of genetic algorithms to the optimal solution. Attempts are also being made to find the optimal stopping time for GAs.

Fractal dimension has been found to be a useful tool to segment an image. Attempts are being made to improve upon the methods of calculating fractal dimensions of images. Attempts are also being made to find the IFS (Iterated function system) code automatically for digital images.

Externally Funded Projects

The Unit has also been conducting three externally funded projects entitled (i) " A neuro-fuzzy image recognition system : Methodology development for forensic applications, (ii) Neuro-fuzzy expert system : Design and Implementation, (iii) Development of Software Package - Handling Uncertainties for Machine Interpretation of Ill-defined Structures present in Gray-level Images". Professor S.K. Pal has been acting as the chief investigator for all the three projects.

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Apart from research activities, faculty members of this unit are engaged in teaching various courses in ISI as well as in guiding research students towards the Ph.D. degree.

1.   Quantum and topological field theory, berry phase, skyrmions, statistical systems, high T_c superconductivity and superfluidity, quantum and topology gravity, quantum cosmology.

2.   Quantum mechanics and quantum field theory by stochastic quantization approach, quantum dissipative systems, black hole physics.

3.   Anyon physics.

4.   Primordial universe : Fluctuation of Maxwell vacuum.

5.   High energy phenomena : The problem of baryonic dictatorship at high and ultrahigh energy; properties of correlation phenomena amongst the secondaries produced in high energy collisions, aspects of intermittency phenomena in high energy collisions ; charge-neutral ratios; underground muon flux; anomalies related with photoproduced showers.

6.   Astrophysics : Neutrino energy sepctrum, magnetic field decay in pulsars.

7.   Sine gordon field theory in curved space-time, Gaussian approach; modified 1/N approach in Dirac field; Supersymmetric quantum mechanics, Solitary waves in plasma.

8.   Rapid distribution theory and coriulis rotation on a turbulent flow. Modelling of turbulent flows with nonlinear terms; deductive theory for a homogeneous turbulent flow. Calculations of turbulence energy spectra.

9.   Uniform thin film on a hot/cold rotating disk. Effect of magnetic field on film thinning.

10.   Scattering and radiation problems, wave maker problems, two-layered fluid problems, problems with bottom deformation; Integral transforms; Integral equations; inventory models.

11.   Sediment transport, dispersion processes Navigation hydraulics, MHD flow and Heat transfer.

12.   Blood flow through artery ; two layer model; hematocrit dependence; temperature dependent viscosity, effects of magnetic field ; blood flow in cardiovascular system.

13.   Multivariable system and control theory; realization; identification and decoupling of multi-input multioutput systems.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes covering plant and animal kingdoms, including humans. It comprises the following units : Agricultural Sciences Unit, Anthropometry and Human Genetics Unit, Biochemistry Unit, Embryology Unit and Leaf Protein Unit. Activities carried out in these units are described below.

Agricultural Science Unit

Members of the Unit participated in the Post graduate teaching of the Calcutta University and continued supervising research work of a Ph.D. scholar.

The Unit conducted research work on 8 ongoing plan research projects and two externally funded projects during the year under review. Project studies have been mainly carried out in two distinctly different agroclimatic regions, namely Giridih region of South Bihar plateau and coastal region in Sundarbans of South 24-Parganas, West Bengal. Farm based studies were carried out in Giridih Experimental Farm of ISI with focal theme on "cropping system improvement through rainfed farming". Agro-sociological studies have also been taken up to probe agro-ecological and socio-economic parameters affecting farming systems in Usri watershed of Giridih region. Overall objective has been to evolve systems suitable for the small and marginal farmers of south Bihar plateau areas.

In the coastal region studies were aimed at (i) introducing suitable cultivators of coconut and oil palm, (ii) detailed botanical studies particularly in respect of palynology, ecology and anatomical characteristics of mangrove vegetation in Sundarbans saline areas. More detailed information about the projects are given below :

1. Cropping system studies

Crop sequence studies could successfully demonstrate success of double cropping in upland with Kulthi and niger as follow up crops with significant productivity increase.

2. Intercropping studies

Hopeful crop combinations with their effect on yield, intercropping advantages and soil fertility status were noted to be positively recommendable for the plateau areas.

3. Crop-varietal performance

i) Trials on different germplasms could establish some potential varieties of paddy, groundnut and niger in difficult upland soils.

ii) Trials on long duration paddy varieties could establish low input fertilizer combinations in organic and inorganic forms for maintaining optimum yield and soil fertility.

4. Agro-sociological constraints of technological adaptation in subsistence farming of Bihar plateau :

In a collaborative study with SRU, survey on Usri watershed with an agro-ecosys- temic approach has been completed and report submitted.

5. Oil palm introduction and coconut improvement in Sundarbans area :

Exploratory work on palmae, leaf anatomical data of Areca catechu in respect of phyllotaxy could successfully establish that left-spiralled plants differ significantly from the right-spiralled ones. A possible relationship of spirality of the plant with yield performance was shown.

6. In studies on performance of oilpalm and coconut, early growth habit of oil palm and coconut in the Sundarbans area were covered.

7. On the Eco-floristic and anatomical investigations on mangroves, significant results were obtained in respect of tracheary elements of stems with special reference to their ecology. In-depth study of morphology and anatomy of the leaf hairs and stomata of the mangroves were done.

8. Studies on weed crop interaction in upland soil conditions of Bihar plateau

From our previous working experience on weed crop interaction effect some new experiments were set up with two principal crops, paddy and wheat, to understand the merits of intercropping, in the light of weed suppressing ability of the supporting crop. In this context we studied the effect of black gram on paddy in the Kharif season and the effect of Bengal gram and wheat in the Rabi season. Analysis of data is in progress.

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Faculty members of the Unit regularly participated in teaching in B.Stat. (Hons.) and M.Stat. courses of the Institute. They were also engaged in supervising scholars in their Ph.D. work.

Research activities carried out by the Unit may be summarised as follows :

1.   Human adaptability programme

This programme aims at (1) evaluating the status of health and well-being of various populations of eastern India in relation to their physiological, biological and socio-economic environments, including the strategies for child survival under urban impoverished conditions, and thereby (2) determining the limits to human adaptation. Recent studies include the study of out-of-home employment on psychological status of mothers and labour productivity in tea gardens. Efforts are being made to study the determinants of mortality and morbidity at various ages, and in impoverished populations inhabiting slums and squatter settlements at the micro-level. Projects 1-5 are being conducted within the general framework of the programme.

Project 1. Health status and labour productivity : Our earlier studies have shown that a labourer's health status does not affect their productive output in tea garden labour population. Similar investigations are being conducted among the agricultural populations.

Project 2. Effects of microenvironmental factors on health in rural populations, phase II : Our study shows that both fertility and mortality have declined between the late seventies and late eighties. A survey on seasonal variation in dietary intakes (4 seasons, one year period) has been completed. Family data on anthropometric and blood pressure have been collected for the purpose of heritability estimation.

Analysis of demographic data on 3 south Bengal populations show that both fertility and child and toddler mortalities decline from the low to high SES groups. Analysis further shows larger intakes of cereals and vegetables in all the 3 groups compared to ICMR recommendations. Intakes of pulses and milk are almost zero among the low and middle SES groups. Data on SES, ailment symptom and food intake have been computerised.

Data on demographic characteristics, marriage patterns, migration are being collected on a squatter settlements.

Project 3. Women's studies : Health and well-being of the child, adults and elderly : Non-working mothers show longer anxiety level than their working counterparts, but the difference is statistically nonsignificant. Anxiety score of nonworking mothers increases with increasing age of children. However the age of mother herself was not related to her anxiety level. Further data on anxiety level of women executives - a high stress group, are being collected.

Project 4. A study on the determinants of fertility and mortality in an urban setting : An anthropological perspective : Both fertility and mortality levels are higher among the Muslim slum dwellers compared to the Hindu slum dwellers. But the Hindu slum dwellers have better perception as well as higher adoption of family planning methods.

Project 5. Human biology of Himalayan populations : Official data on health status of the Dzongu populations have been compiled. Some health related data on the Lepchas of Dzongu area are being collected. Background information on prevalence of goitre in the Dzongu area being collected.

2. Study of physical growth of the Bengali children

Physical growth data on height, weight, skinfold thickness and menarcheal status have been collected from 300 Calcutta based Bengali school going girls. A repetitive survey is planned during the current year.

3. Rheumatoid arthritis

About 2,000 families with 11,000 (approx.) individuals have been surveyed in some villages of Nadia district to estimate age and sex specific prevalence of Rheumatoid Arthritis. Suspected rheumatoid arthritic cases were clinically evaluated by a clinician for final clinical diagnoses. A blood sample was collected from each patient. Laboratory investigations of blood samples have been done. Further screening is in progress.

4. Man-Environment Interactions

Investigations are being conducted among some tribal groups of Manipur who are undergoing and have undergone rapid transition. The effect of this transition in changing the relationship between forest and people in the predominantly shifting cultivator tribals of Manipur and its implications both to the people, and to the health of the forests are being studied. A research student is working for Ph.D. on this problem.

5. Population variation

Laboratory analysis of about 1,000 blood samples from ten different endogamous populations, collected from north India, have been done for 18-20 markers including the level of immunoglobulin and HTLV-I. From these analyses some enzyme and protein variations were found. Further screening is in progress.

Research was carried out in the area of population genetics and haemoglobinopathies. Haemoglobin S is highly prevalent in central Indian tribes (Das et al 1993) but little was known about its spread in the region. Our recent studies have enabled us to understand that migration of kin groups of particular populations, not necessarily inversely related to geographic distances, and admixture across linguistic barriers are the sources of spread of HbS gene in the region. Secondly, little was known about maintenance of Hb in high frequencies (0.61) in some populations of eastern and north-eastern India. Our studies have provided some clues, for example, cooccurrence of alpha-thalassemia in high frequencies which lowers the B+ thalassemia like expression HbE; asymmetry in migrational patterns between generations may also have attributed to the observed fluctuations in gene frequencies between generations of a population.

6. Genetic epidemiology

(a) Research was conducted in the area of genetic modelling and analysis of multilocus traits. Statistical methods appropriate for the analyses of family data on a multilocus trait with variable age at onset were developed. A genetic model for vitiligo proposed by us earlier was successfully cross-validated and robustness studies were conducted. The significance of these studies lies in the fact that development of statistical methods for analyses of family data under multilocus models is only beginning to get attention in the field of genetic epidemiology.

(b) Research was carried out, in collaboration with the University of Pittsburgh, to map genes for abdominal aortic aneurysm (AAA) - a vascular disorder found to be recessively inherited by us earlier. Even though it was postulated by others that AAA is a defect in collagen metabolism, our statistical and laboratory analyses have conclusively revealed that none of the collagen loci is genetically linked to AAA.

(c) A genetic analysis of family data on blood pressure collected by us on Marwaris of Calcutta has revealed that when blood pressure measurements are adjusted for effects of obesity (primarily body weight and skinfold thickness), there is no genetic transmission of the residual blood pressure levels. We have postulated that effects of the genes controlling blood pressure levels are mediated through secondary variables, such as obesity.

(d) An epidemiological study of blood pressure was conducted in collaboration with Dr. A. Nirmala and other colleagues from S.V. University, Tirupati, among the socioeconomically contrasting populations of Andhra Pradesh, including entire range of life style backgrounds. The results demonstrate an unambiguous effect of changing life styles (towards urban mode) on the rise in blood pressure, and related cardiovascular problems.

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7. Dermatoglyphics

Studies in this area include (a) development of new ridge counting techniques of palmar and plantar patterns, scoring of hypothenar triradii and designing a few new variables, (b) population variation, (c) bilateral asymmetry, (d) sex variation, (e) inheritance of dermal traits, (f) inheritance of dermal asymmetry and (g) genetic disorders.

The results obtained confirm that (i) the dermatoglyphic traits in general and palmar characters in particular do help in understanding the biologic (ethnic) affinities among different ethnic groups, (ii) the different types of traits which are influenced by different genetic and environmental factors give rise to different clustering patterns and (iii) studies in the area of dermatoglyphic asymmetry would focus on a better understanding of the hypothesis of developmental homeostasis in man which is an important aspect of recent interest in the field of anthropological genetics.

The work done during this period includes a complete analysis of qualitative traits of toe and finger prints from five different population groups (500 males, 500 females). Scoring of quantitative traits of palmar and plantar dermatoglyphics are in progress.

Biochemistry Unit

Faculty members of the Unit participated in teaching in the B.Stat (Hons.) course of the Institute and also at the Calcutta University. There were, in addition, scholars working for their Ph.D. under the guidance of the faculty members.

1. Cancer chemoprevention

(a) An approach towards cancer control : Three projects are on-going on uterine cervix cancer prevention through nutrient intervention. These are (a) Development of biochemical/immunological assay system for nutrient analysis, mainly folic acid and betacarotene.

Conventional microbiological methods for determination of folic acid are time consuming and laborious. A simple assay using *Streptococcus faecalis* in a 96 - well tissue culture plate (micro-assay) and automatic plate reader has been established. Sensitivity of the assay has been increased 5-fold over the conventional assay; the standard curve ranges from 0.1-10 ng/ml. Assay for human blood samples are in progress.

The clinical application of the newly established enzyme immunoassay for folic acid is currently being tested on sera obtained from subjects with (i) neoplastic diseases ; the work is being done in collaboration with the Indian Institute of Chemical Biology and Cancer Centre and Welfare Home, Thakurpukur, (ii) different kinds of anaemia. The folic acid levels are compared with the haemoglobin status.

(b) Detailed statistical analysis and mathematical modelling of the data collected from Calcutta Medical College and Hospital was completed. Based on the model(s) a 'Biological Ageing Index' (BAI) on the evolution of the diseases, namely (0.014) ACM + (0.05) EP has been constructed. Also, parity (P) in association with age at the consummation of marriage (ACM) and sexual exposure period (EP) comes out as a significant 'risk factor' for the development of dysplasia.

Cancer related epidemiologic data on the general population of Domjur, as well as on the sex professionals are currently being analyzed.

(c) No progress can be mentioned except that the cell culture laboratory is slowly taking shape in the project 'In Vitro Model Cervical Cells'.

In phase II of the Genetic Epidemiology of Blood Pressure study, dietary and other epidemiologic survey work has been started on Marwari families along with biochemical parameters (as in phase I). The criteria for selection of a family is to have at least one hypertensive patient (proband) in the family. During

past year dietary history and biochemical estimation of blood sugar, serum-urea, total cholesterol, and lipid fractions were done on 170 subjects.

These will be utilized in order to find out whether any dietary 'risk factor(s)' can influence the development of hypertension.

2.   In the programme on Epidemiology of Rheumatoid Arthritis (RA), analyses of blood samples from 100 suspected RA cases have been done during the past year. 30 cases were seropositive. ESR values were also found to be high in seropositive cases. Serum calcium and alkaline phosphate levels are also being measured.

Embryology Unit

Faculty members of the Unit participated regularly in teaching Biostatistics in B.Stat (Hons.) and M.Stat. degree courses of the Institute. Details of research work carried out by the Unit in the form of projects are reported below :

1. Mathematical and stochastic modelling of cellular growth, differentiation and morphogenesis during embryonic development and carcinogenesis.

A few new non-linear reaction diffusion, spatial-temporal, mathematical and stochastic, models of pattern formation and morphogenesis modifying the existing ones have been proposed and analysed. Since global stability of the pattern thus evolved is the most important point for consideration, all the spatial systems studied have been analytically investigated for their global stability properties in one and two dimensional geometry using suitable Liapunov functions. In some cases the three dimensional behaviour of the systems have been observed numerically by using superfast computer. Bifurcation theories, catastrophe theories and system analysis have been used to study the non-linear systems.

One component and three components reaction-diffusion models involving spatially variable diffusion coefficients based on the concept of contact cell inhibition of mitosis have been proposed and analytically studied to shed some light on one of the possible mechanisms of carcinogenesis and tumour growth.

2. Intercrop interaction - a mathematical study on agricultural ecology

A repetition of field experiments on intervarietal interaction between two pairs of varieties of rice : (i) patnai vs. pankaj and (ii) patnai vs. IET 1449, was conducted in Giridih farm, Bihar. This study was aimed at confirming our earlier observation on intervarietal allelopethic effect through root exudates. Our earlier findings of significant differential effects at different spacings suggest that root exudates (of one variety) containing activator and/or inhibitor diffuse through the soil and undergo chromatographic separation in the soil. Two clear cut inhibitor & stimulator of short length have been isolated. The inhibitor with lower Rf coincides with one of the two presumable phenolics.

A comparatively rapid and efficient technique using descending chromatography has been utilized for eluting these inhibitor & stimulator molecules. This is now ready for GLC and Ms analysis which will identify the molecules.

3. Mathematical epidemiology

The dynamics of Japanese Encephalitis (J.E.) have been studied by constructing mathematical models. The validity of these models with its conclusions have been verified by the data of J.E. in Memari Block II (with high prevalence rate) and the Burdwan district as a whole in West Bengal, India.

The frequency of occurrences of J.E. during different months of the year 1986-1990 in Burdwan district of West Bengal, India, has been studied with the help of a mathematical model using a third order harmonic Fourier series having a linear trend. This model seems to have a wide universal application where

predominant seasonal effects prevail. The development of immunity in the susceptive class by low level exposure to infection, a commonly observed phenomenon in cases of many infections diseases have been incorporated in the existing SIRS model and has been extended by coupling the dynamics of the disease in two populations.

To study the spread of the dreaded disease, 3 – population system namely vector, reservoir our and human population have been considered where the vector and human populations are varying in size whereas the size of the reservoir population is fixed.

4. Mathematical and computer modelling of the cellular and molecular details of how the animal's embryonic body plan in established.

The mechanism of cellular differentiation and pattern formation in the developmental stages of growing embryo has been investigated with the help of a reaction-diffusion model in curvilinear coordinates namely, cylindrical and spherical. Model analyses have been performed in two phases. In the first phase it has been observed that (a) the bifurcating curves in the parametric space have no resonance point. (b) when the growing embryo reaches upto a final pattern, the morphogen gradient which serves the purpose of positional information within the embryo will vanish. Thereby it may be concluded that after getting a final pattern there is no longer any need of "Positional Information", (c) active counter transport of micro - molecules e.g. morophogen, plays the vital role of getting Turing structure in the epigenetic system.

In the second phase it has been observed that the information of the pre-assigned gradient of certain known gene products (biologically a more realistic phenomenon) on the reaction kinetics dramatically affects the behaviour of the system. Major results in the second phase are : (i) there exists two gradient systems, namely a pre-assigned gradient responsible for large scale global pathway and a local gradient, (ii) due to the effect of the pre-assigned gradient a repetition of pattern may be obtained along the anterior - posterior axis of the growing embryo, this may also be described as a sort of metamerism, (iii) for some higher values of the pre-assigned gradient, this repetition may lead to a 7 - band structure in growing embryo, which may also be regarded as a first approximation to the seven bands of the Drosophila larva.

Leaf Protein Research Unit

The major thrust of the work done in the Unit was on the proper selection of suitable sources for leaf protein production, their quality parameters, experimentation on animals & humans to judge its effectiveness for supplementation in diets, economics of production and utilization of the two main by-products, i) whey and ii) the fibrous residues.

Brief information about the projects are given below :

1. Screening & agronomic studies on various plant species including fodder crops, tree leaves and aquatic weeds for leaf protein production. A number of plants have been found to be promising.

2. Agronomic studies on sugar beet crop as an alternative source of sugar, alcohol and leaf protein as a by-product have been conducted . It was found that a reduction of sucrose percentage as a result of high nitrogen doses could be checked by the application of potassium fertilizers.

3. Biochemical and nutritional studies have been made on leaf proteins prepared from the above mentioned sources followed by protein quality studies on promising sources. When leaf protein from Ailanthus excelsa, a tree leaf, was supplemented at 25% to a soyabean diet, the growth of chicks fed on this diet was comparable to those fed on the standard diet.

4. A project on human feeding trials to study the improvement in health and economic status of two communities by intervention programme using leaf concentrates has been taken up. The feeding trial has been completed. This project is externally funded by Find Your Feet, London.

5. Utilization of the fibrous residue left after leaf protein extraction is being tried out. The possibilities being considered are :

a) As a source of fodder materials : Palatability trials on cows using fibre samples of a promising tree, Samanea saman, showed that it could be used as a feed.

b) For mushroom production : chemical analysis of an edible mushroom, Pleurotus sajor-caju, collected from different fibrous by-products and agricultural residues have shown it to be a good source of proteins and minerals.

c) On isolation of cellulolytic enzymes from soil microbes : Encouraging results on the production of cellulose in the culture filtrate of Aspergillus fumigatus has been obtained. This enzyme will be used for saccharification of pre-treated fibrous residue.

Social Sciences Division

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Planning Unit, Population Studies Unit, Psychometric Research and Services Unit and Sociological Research Unit. The Economic Analysis Unit is located at Bangalore, the Planning Unit is located at Delhi, while the remaining five units are located at Calcutta. Faculty members of these division were engaged in teaching and training activities at various levels, including Ph.D. supervision. The research work done in these units during the year under review is described below.

Economic Research Unit

Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and research courses in economics as well as in other training courses conducted at ISI, Calcutta. Several faculty members participated in the teaching programme of other universities also and served in many technical and expert committees of Government and other organisations. There were, in addition, a number of research fellows working for the Ph.D degree under the supervision of faculty members of the Unit. Three research scholars have submitted their dissertations for the degree from ISI and one scholar from outside ISI has completed all the requirements for the award of the degree of ISI under the supervision of one of the faculty members of the Unit during the period under reference.

The research activities of the Unit during the period under review covered fields like economic theory, macro-economic policy, industrial economics, welfare economics, demand analysis, income distribution, level of living and poverty in India, agricultural economics, economics of informal sector, economic development etc., besides other investigations in applied economics and methodological studies in econometrics. Research in the following areas may particularly be highlighted for the period under review.

1. Economic Theory

Research work has been going on over the past several years on various areas in economic theory. Mention may be made of rent-seeking theory, industrial economics, economic efficiency and welfare economics. Attempts have been made to characterise the Shanon-Theil inverse concentration formula using a principle which requires concentration to increase under horizontal merger of two or more firms. A measure of the size of welfare loss resulting from rent seeking within the government budget has been formulated. Another work looks at the social-welfare implications of relative deprivation ordering generated by two non-intersecting relative deprivation curves.

2. Economic Development

A study has been made to analyse industrial dualism, vertical specialisation and credit policy. Attempts have also been made to study the formation of agricultural prices and growth and instability in agricultural production in India. The problem of modernisation, employment and foreign borrowing has been dealt with in another paper.

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3. Macro-economic Policy in India

Several analytical work in this area have been undertaken. One study considers the issues in financial liberalisation. In another, an attempt has been made to examine the agricultural policy with respect to current liberalisation programme. Attempts are also being made to develop appropriate analytical framework for a rigorous analysis of current macro economic problems.

4. Income and Level of Living

Various aspects of income and level of living have been examined in a number of studies. The study which was undertaken at the instance of Department of Statistics, Government of India, examined the suitability of some alternative simple criteria for identifying the rural poor. Preliminary results have already been released and communicated to the Department of Statistics. The findings have also been presented at two workshops/seminars on Poverty - one at NIRD at Hyderabad and other at ISEC, Bangalore. Another study based on NSS 38th round household budget data showed that Engel elasticities of items like clothings change dramatically if one utilises data for the last year reference period, in place of data relating to the last month reference period. This shows the need for using appropriate techniques for estimation of Engel relations when the data relate to short reference periods like last month or last week. Instrumental variables estimation or method of moments may be superior to OLS method. Work on the analysis of time trends of the extent of inequality, poverty and level of living continued during the year and some results have been released for the urban and the rural people separately.

5. Econometric Methods and Applications

A considerable amount of research has been carries out on various topics in Econometrics, e.g., (i) estimation of linear regression models, (ii) testing under non-standard conditions, (iii) dynamic model, (iv) stochastic modelling, (v) estimation of deviations between measures of real and nominal value-added shares of GDP, and (vi) frontier production functions.

6. Other Studies

The statistical-linguistic analysis of Rabindranath Tagore's works reached the final stage. The project had been undertaken in collaboration with the Institute for study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies. The first report on Gitanjali would be published shortly. The manuscripts of two other reports - one on three poetical works (*Sandhya*-Sangeet, Prabhat-Sangeet and Manasi) and the other on prose works (Galpaguchcha, Sabhyatar Sankat and Lipika) - are under preparation.

Externally Funded Project

A draft report on the "Differential Impact of Modern Rice Technology on Favourable and Unfavourable Environments" based on 60 sample villages in West Bengal was circulated to experts for comments. The report is now being finalised in the light of the suggestions and comments received from these experts. The study is concerned with identifying the determinants of modern rice technology adoption and also with assessing the impact of such adoption on cropping intensity, factor shares, labour use and household income, poverty and inequality.

Economic Analysis Unit (Bangalore)

Economic Analysis Unit (EAU) staff taught courses on index numbers, official statistics and time series analysis for M.Stat. students. A. Ganesh Kumar, Senior Research Fellow, has submitted his Ph.D. thesis on "Stability of Cereal Crop Yields' Performance : An econometric analysis for India & Andhra Pradesh", under the research guidance of N.S.S. Narayana.

The unit carried out, besides teaching research in certain areas of economic theory, econometric methods and applications during the year. Important problems and areas in which the faculty remained actively engaged are (i) Computable general equilibrium model for India focussing on separate treatment of non-agricultural sector as tradable and non-tradeable components. This, coupled with a reasonable disaggregated agricultural sector, facilitates assessment of trade liberalization policies pursued in India with regard to their economic impact on production, international trade, price levels and pattern of income and consumption distributions. (ii) work on growth, variability and stability of crop yields in Indian agriculture involving application of nonlinearity measures while estimating yield functions are continuing. (iii) Another area of research that is pursued is consumption distribution with emphasis on how to compare inequalities in a statistically- acceptable way. (iv) On history of economic thought and structure of Income Determination in Kalecki's Macro System. (v) Bayesian Vs. Classical approaches with regard to modelling size distribution of incomes. (vi) Total factor productivity in Indian Industry and also impact of structural reforms programme on Indian economy.

Planning Unit (Delhi)

During the year under review, the Planning Unit was engaged in teaching and training at various levels, both in the Institute and in other Universities, and research in the disciplines of Economics and Sociology.

Members of the unit participated in the regular teaching in the degree and research courses in economics as well as in the ISEC and ISS training programmes. There were also a number of research fellows working for the Ph.D. degree under the supervision of the faculty members of the unit. One of them got the degree and another scholar submitted his dissertation during the year.

Research in Economics covered a large number of areas, both theoretical and empirical. Theoretical research revolved broadly around problems of Optimal Tax Enforcement and Corruption, Social Choice, Public Goods, Implementation Theory, Game Theory and Macro Theory & Disequilibrium economics. Empirical and applied work also covered many problems, viz., Growth, Distribution & Poverty in India, Economic Reform & the Structural Adjustment Programme, Supply Response functions in Agriculture, Input decisions in the face of risky Agricultural Production, Consumer Price Indices and their comparability etc.

Apart from publishing scientific papers in journals and books, members of the faculty are also engaged in project work. Amongst these were the projects on "Reforms in Indian Income Tax Enforcement", "India's Exports to European Union : Constraints and Prospects", and "Fiscal Reform and Structural Adjustment : Micro and Macro Dimensions".

In Sociology, attention was focussed on Social conflicts in India, Nationalism & Nation-building, Agrarian structure etc. There is an ICSSR-sponsored ongoing project on Agrarian conflict and Rural Labour which seeks to look into the phenomenon of agrarian conflict as it is affecting rural labour in the feudalistic agrarian region.

Linguistic Research Unit

During the period April 1993 to March 1994, the Linguistic Research Unit continued its programme of research in the areas of Fundamental/Applied Linguistics and Computational linguistics with special emphasis on Speech Pathology, Psycholinguistics, Socio linguistics, Syntax and Text Analysis. There are five main headings under which the unit's research projects may be grouped, namely :

1.   Studies on the phonetic structures of major Indian languages and application of the results in the areas of : (a) Speech Pathology; (b) Second Language Acquisition (c) Cultivation of Mother-tongue (d) Language Standardisation (e) Comparative suprasegmental studies on Indo Aryan, Dravidian and Slavic.

2.   Sociolinguistics : (a) Study of language attitudes, (b) language maintenance and shift and (c) measurement of bilingualism.

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3. Socio/Psycholinguistic aspects of cognition in relation to Language, Class and Creativity.

4. Bengali syntax and Semantics related to natural language processing.

5. Application of Statistics to Linguistic problems : Computational Text Analysis.

6. Archaeology of Bangla Grammar : Using Post-Structuralism to understand the problems of Bangla Grammar under colonial rule.

7. A study on language movements in India, in the context of socio-political planning, with special emphasis on lower strata pressures and dimensions of change.

8. The unit also carried out habilitation programmes for the hearing impaired children with related speech disorders.

2. On-going Projects

1. Assessment of articulatory performance in hearing impaired children - the relevance of the Kostic classification

A sample of fifty children between the ages of 5 to 10 years with Bengali as L1 were tested in Calcutta using the Kostic, Mitter (1982) test for articulatory evaluation of Bengali speech sounds. Another set of 25 children between the ages of 5 to 10 years with Telugu as L1 were tested and classified using audiometric tests and articulatory tests of Telugu speech sounds (Kostic, Mitter and Krishnamurthy, 1982).

2. Study of Suprasegmentals of the Hindi Language

Syllable stress in a sample of 50 disyllabic words containing combinations of open and close syllables were tested from 20 native Hindi speakers residing in and around Calcutta. Sentence melody and intonation patterns were also studied and analysis has been carried out on the Visipitch. Further data have been collected from another sample of native speakers of the language mainly from the areas of Delhi, Allahabad and Agra. The next phase of the project will be dealt with in the project on comparative suprasegmentals.

3. Study of the Suprasegmentals of the Telugu Language

Syllable stress in monosyllabic, disyllabic and polysyllabic words has been studied and some preliminary analysis has been carried out on the Visi-Pitch. The next phase of the project will be dealt with in the project on comparative suprasegmentals.

4. Comparative Suprasegmentals of the Slavic, Indo-Aryan and Dravidian languages

Fresh data were collected from new linguistic areas, both Indo-Aryan and Dravidian. The influence of affective meaning in isolated words was studied in contrast to the same words within sentences.

5. Study of the phonetic structure of the Tamil language

Data of Tamil phonemes was processed to obtain the first set of spectrograms of Tamil speech sounds from which the acoustic structure of Tamil phonemes is to be established.

6. Survey of the articulatory norms in Bengali speaking children of Pre-school age

50 pre-school children between the ages of 2 and 4 years were tested using the Kostic and Mitter (1982) test for articulatory evaluation of Bengali speech sounds, in order to study the norms of articulation for each age in that age group. Natural Generative Phonology framework (Vennemann, 1970, Hooper, 1976) was used for analysis.

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7. Educational problems of hearing impaired children attending schools for normal children

A set of questionnaires to test the attitude and awareness of parents and teachers on the process of habilitation and education of hearing handicapped children attending general schools were administered on 50 parents and 50 teachers of hearing handicapped children. The tests were also supported by interviews of both teachers and parents. The results of the test are meant to highlight the shortcomings of both the social land the academic establishment, on their approach to habilitate the hearing impaired child. Special awareness programmes were also launched in this connection.

Completed projects

1. The concept of Crippled Creativity and correlation of class and codes

The fundamental and applied research have been completed. Results are presented at the Social Science Congress and two technical reports have been brought out in this connection.

2. On the heterogeneity of Kolkata Dialects

An attempt has been made to deal with the problem of standardization of the dialects across the districts of Kolkata. For this purpose a survey of the North Kolkata Dialects was carried out. The results have been released.

Population Studies Unit

Faculty members of the unit were engaged in teaching demography in B.Stat.(Hons.) and M.Stat. courses of the Institute. They also participated in the teaching of ISEC courses, Diploma in Health Statistics Course of the All India Institute of Hygiene and Public Health. Providing guidance to research scholars for doctoral work also continued.

A. Externally funded projects (On-going)

1. Attainment Level of Primary Students in West Bengal

The study was conducted in all the 17 districts of West Bengal to evaluate the performance, in an independently formulated test, of the students at the end of class IV. Only the scholastic areas (e.g. vernacular, mathematics and environmental science) were included in the first analysis. A two-parameter logistic model was used for analysis and deriving scores. The model had been found to be useful for assessment, and could also be used for pedagogical research so as to help reorganising materials for learning and improving teaching-learning process.

Externally funded projects completed

1. Impact of Total Literacy Campaign (TLC) in Bankura District, West Bengal

Short term impact of TLC is the main focus of the empirical study. In order to discern the impact of TLC on the reflective domain of the learners, two types of appraisal were carried out. It is found in course of attitude measurement that the female participants in the TLC programme showed more positive attitude compared to female illiterates. As far as participation in TLC is concerned, the ever-married females, the scheduled castes and the scheduled tribes were the most noteworthy.

2. Impact of Total Literacy Campaign (TLC) in the District of Birbhum, West Bengal

The main purpose of this short-term impact study was to maximise the long-term impact and efficiency of the TLC programme by rapidly identifying useful leads and experiences, and feeding these back into the operational framework.

B. Plan project

Micro-regional statistical surveys in India upto 1875

The study has been undertaken to analyse the statistical materials on land and people of the 20th century. Data sources for the study are the national and state archives of India. Using the data, a number of analytical studies have been completed.

C. Non-Plan Project

Study of incidence of Nepali migrants to India

The study of Nepali migrants to India in general and to West Bengal in particular is based on census data. It attempts to estimate inter-censal migration and annual volume of migrants based on a structural graduation model, and return migration. The project has been completed.

Psychometric Research and Services Unit

Research work done by the unit during the period is briefly summarized below projects.

1. Potential Entrepreneur School Leavers

The study undertaken with the objective to identify potential entrepreneurs from among the young boys and girls who can independently start some business or manufacturing units for their livelihood after their high school education continued. During this period data collection have been done from trainees undergoing Entrepreneurship Development programme at three centres of West Bengal viz., Uluberia, Bolpur and Bankura. Data from some successful Entrepreneurs from Bangalore have also been collected.

2. Motivation to work for Primary level workers

This is also a continuing project. Its objective is to develop a questionnaire for assessing the motivation level of different groups of workers for e.g., Clerk, Typist, Factory worker etc. A preliminary questionnaire with two parallel forms have been prepared. Data from 50 clerical workers for the pilot study have been collected.

3. Personality pattern of different occupational groups

Attempts are being made in the ongoing study to determine personality profiles of four occupational groups viz., teachers, executives, artists and Bank Managers. Sixteen personality factors of four occupational groups were measured by Cattell's 16 PF. Stepwise discriminant analysis shows that of the sixteen factors, only five personality factors can predict the differences among four occupational groups.

4. Consequences of social and economical deprivation on academic achievement

Prolonged socio-economic deprivation is likely to have important effects upon the scholastic achievement of School going children. The study taken up to investigate about such effects on students reading in Class X in different districts of West Bengal continued this year also. The important findings are (a) Though intelligence is the most important determinant of academic achievement yet the influence of some non-cognitive factors such as achievement motivation, prolonged socio-economic deprivation are never negligible. (b) Prolonged deprivation adversely affects academic achievement, development of intelligence, etc., (c) the nature of this relation varies across sex and region. Report writing has been completed.

5. Assessment of Minimum learning in Primary education

First volume of the final report has been published. Preparation of second volume is in progress.

Some members of the unit also participated actively in a number of other externally funded projects details of which are reported elsewhere.

Surendranath Banerjee, one of the staff members of the unit, submitted a dissertation entitled "A study on the Impact of Minimum Learning Programme on the Performance measures of Bengalee children in the primary school leaving class" for the Ph.D. degree of the Calcutta.

Sociological Research Unit

Research activities carried out by the unit may be summarized as follows.

1. Pressure from below : A study of the Impact of the Popular Movements in 1940s'

To find out the data base of the Tebhaga Movement in Birbhum, five types of source materials, most of which have so far remained untapped, were explored : (i) the records of the District Courts, (ii) the files on FIR shelved in the relevant Police Stations, (iii) the old journals of the district, (iv) the organisational reports of the *Krishak Sabha,* and (v) the tape-recorded interviews of the leaders and participants in the Tebhaga uprisings in Birbhum. Collection of rare source materials is over. Collection of archival data and exclusive interviews with the leaders have been completed. Report writing is in progress.

2. Haldia : A study in the Linkage of Population and Development in an Industrial Complex

An attempt is being made to identify the linkage between population demography and Industrial effect with regard to the potentiality and carrying capacity of the growing industrial complex, Haldia. It will also try to understand the socio-economic availability between core population and fringe group with respect to their quality of life. Field work being over, data-processing, analysis, and report writing are underway.

3. Social Ecology of Minority/Marginal Group of Eastern India

This is a study of the inter-connection between the eco-condition and the emergence of Social polarization, if any, over and above the economic differentiation between castes of different strata. A technical report has been prepared.

4. Dissemination and Adoption Process of New Technology in Agricultural Activities of Tribals in Village Situation

The study seeks to identify the process of diffusion of new technology in agriculture among the backward tribal communities and to suggest ways for proper extension technology to be used by them. The report writing is underway.

5. Agro-sociological Constraints of Technological Adaptation in Subsistence Farming of Bihar Plateau Region

The objectives of the study are to (i) identify the nature of indigenous farming system and multiple cropping varieties in the Bihar plateau region, (ii) explore the present resources, and examine the present strategies of the farmers to ensure subsistence, (iii) Understand their perception, behaviour and rationalisation towards decision-making and, (v) assess the feasibility of adoption of new technology by resource poor farmers. Transcription of data collected in the last year as well as in this year is underway. Tabulation of secondary data on agricultural production in the study area and Giridih district is being made. Collection of data on activities allied to agriculture is underway.

6. Inequality and Distribution of Gains in Tribal Societies - A pilot study

This is a study on development in tribal areas and the distribution of development inputs among tribal families of different economic strata through ITDP and other poverty alleviation programmes in the last two decades. The study seeks to test the hypothesis that there has been increasing inequality among the tribal

households through development. Collection of data, transcription and tabulation of village level and household level data of one district are over. Field work in other districts of West Bengal is being undertaken.

Debasish Bhattacharya and Bholanath Ghosh attended a ten week course or monitoring and project evaluation at the University of East Anglia.

Statistical Quality Control and Operations Research Division

The Division continued its activities in developing professionally competent specialists in Quality Control, Reliability and Operations Research (QCROC), imparting inplant appreciation and techinical training in the tools and techniques of QCROC, undertaking project studies and service assignments in addition to theoretical and applied research to develop and improve methodologies in the relevant fields.

The Division continued its activities in the folloiwng areas :

1. Developing professionally competent specialists in Quality Control, Reliablity and Operations Research (QCROR) for industry, trade and service sectors through various courses leading to Degree, Diploma and Certificates.

2. Imparting inplant (industrywise and general orientation), appreciatlion and technical training in the tools and techniques of QCROR to scientists, managers, executives, supervisory staff, and even workers.

3. Undertaking project studies and service assignments in all aspects of Quality and Reliability management relating to organisation, development, training and research in QCROR for improvement of quality, productivity and efficiency and reduction of cost of goods and services.

4. Promoting the use of Quantitative tools and adoption of modern methods of Qaulity Management through seminars, conferences, lecture programmes and promotional talks.

5. Undertaking theoretical and applied research to develop and improve methodologies in the relevant fields.

The new activities pursued by the Division included the following :

1. Follow up of INDO-US-Japan Conference held during Prof. P.C. Mahalanobis Birth Centenary Celebrations at Bangalore to organise Indo-Us-Workshops on process and product Quality Improvement through Experimental design (4 days) and Quality through Malcolm Baldrige Award criteria and competitiveness (one-day) in different centres.

2. Starting a follow up project on Enumeration of Mail through Sample Survey in West Bengal and Delhi for the Dept. of posts, Ministry of Communications, Govt. of India.

3. Inducing two batches of Quality Mission Executives and organising 3- months orientation programme for the first batch to equip them in organising training programmes on ISO-9000, TQM, SPC, Audit etc. for industries and service organisations.

4. Organising a special 3-day programme on behavioral aspects in management interface for the staff of the Division conducted by the Indian Institute of Management, Bangalore.

There has been an all round increase in the various activities of the Division in response to the growing demand for our services.

During the period under review, 16 plants became new clients and a total of 113 organisations were taking our consultative services at the end of March 1994. About 196 projects were carried out in different organisations. The problem areas involved are (a) optimisation of process parameters, (b) improvement in productivity, (c) improvement in quality and reliability, (d) reduction of cost, (e) introduction of quality system, (f) development of software for various system etc.

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Consultancy services are now being rendered to a number of organisations desiring to achieve registration for ISO 9000 standard for Quality System. Already 4 members have got the certificate and several organisations are at the final stage of audit. Salient features of a selected few projects are as follows :

(a)   A new cost efficiency Compressor Model for Coolers and Mini-Refrigeration was developed which helped the Company to incorporate best features of world leaders.

(b)   Optimum proportions of different Quartz Grain size was arrived at using mixture design and multiple regression for better functioning of the Fuse to successfully interrupt short-circuits without developing any cracks and with minimum let-through energy before fusing.

(c)   Optimum levels of different process parameters were arrived at using Design of Experiments which helped consistency in Alk-Cell preparation in Staple Fibre Industry which in turn helped to improve the product quality of the Fibre.

(d)   Variability of Gold plating Thickness was reduced from $\pm$ 3. 0048 to $\pm$ 0.83 through experimental approach in a watch plant.

(e)   Process standards are achieved through Design of Experiment to reduce the defect levels from 15.7 per board to 0.2 per board.

(f)   A mathematical model has been developed based on approach of P.Y. Wang (OR 83) for obtaining Optimal cutting plans and the necessary software was also developed using FORTRAN 5.1 version. Cutting Plan is under trial implementation and expected to generate a savings of Rs.33 lakhs per annum.

(g)   A modified method of Spacer was developed and the yield of cathode spacer in TV Electron Gun was improved from 80 to 98 together with reduction in setting time from 1/2 a shift to 2 minutes.

(h)   A study was conducted to evaluate the possibility of reduction of the Microbial Burden in crude drugs by heat treatment so that the count is within the pharmacoepial limits of export countries. Result suggests a significant reduction with respect to the total enterobacteriaceea and total fungal count.

(i)   Cost effective preservative system for Drug was developed through experimentation which has resulted in savings of Rs.12 lakhs per annum apart from improving the quality of the product.

During the period 12 papers by the scientific staff were either published or accepted for publication in the national and international journals; another 13 papers were presented at conferences, 13 papers submitted for publication. 26 manuals and technical reports were prepared. Some of the areas of work are (a) Bayesian acceptance sampling plans, (b) Continuous sampling plans, (c)Fuzzy goal programming in acceptance sampling, (d) Life test experiments, (e) Reliability optimisation, (f) Parametric design and global optimisation, (g) Linear complementarity problem, (h) Convex function, (i) Invex and pre-invex functions, (j) Charaterisation of p-matrices, etc.

Apart from the academic (M.Stat. and M.Tech. in quality Reliability and Operations Research in Calcutta, Delhi and Bangalore) and professional courses on Quality, inplant training programmes for Managers, Executive, Supervisory staff and operators were continued during the period under review; a total of 7,356 persons at various levels had undergone training through 278 inplant general and other courses. The increase in the number has been quite phenomenal. The cell for specialist Developement Programme has been organising relevant input programme for SDP fellows and newly inducted Technical Officers of the Division.

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

1, The preparation of a manual for the construction of a classaurus.

2. The designing of a "Classaurus" for the depth indexing of micro subject going with the base, agriculture and related science and technology.

3. The demonstration of the use of the above mentioned classaurus.

4. The application of the "Colon Classification, ED. 7", for the purpose of (a) arranging documents and for (b) documentation work and service.

5. The designing of "Multi-Access Thesaurus".

6. The study of the varieties of "Thesaurus-structures formats" from the point of view of their impacts on information retrieval.

7. The study of various method of knowledge representation, such as, semantic nets, frames and predicate calculus and of their related features to ascertain their co-relation with the classificatory language of colon classification.

8. The designing and developement of National depth classification schemes, Thesauri and claassauri for the depth indexing of micro subjects going with various recognized disciplines.

9. The application of the "Modern Scientific management techniques" to the planning and management of information systems, Centres and services.

10. The study of the methodologies of information analysis and consolidation.

11. Preparation of state-of-the art report on "Performance standards in the field of secondary information work and service".

12. The developement of bibliometric measures for evaluating the use of library and information services.

13. The preparation of guidelines for developing software and application packages for house keeping operations of information centres, such as, circulation control service control and acquisition control.

14. The developement of a computerized manpower planning model for information centres.

15. Restructuring of curricula and syllabi specially for the advanced courses on "Information Science" including "Documentation" and "Library Science" with a view to accomodate essential contents pertaining to the use of the machines and equipment which are allI results of advances in information technologies.

16. The developement of a computerized tutorial for CDS/ISIs (Mini-Micro Version).

17. Natural Language Processing and Vocabulary control for Information Retrieval.

18. Developement of PROLOG-BASED vocabulary control Devices.

Externally Funded Project

There is one externally funded project under the control of DRTC. This project is the "Short term training programme of computer applications to library and information work". It is specially meant for the professionals in the field of information work and services. It is fully financed and sponsored by the National Information Systems for Science and Technology by the Department of Scientific and Industrial Research, Govt. of India, New Delhi.

Programmes of Activities

The activities of DRTC have been organised into several programmes, such as the following :

1. Research programme ;
2. Advisory service programme ;
3. (i) Extension programme ;
   (ii) Publication programme ;
4. Educational and training programme ;
5. Employment information programme ;
6. Continuing educational and training programme ;
7. Faculty development programme.

Training in Documentation and Information Science

1. Course leading to "AIDS" Award

Under its Education and Training programme, DRTC conducts a course of 24 months duration leading to the award "Associateship in Documentation and Information Science" (AIDS). This award is recognized by Govt. of India as equivalent to a Master's Degree in Information Science.

2. Short term course on computerized Information work and service

Under the sponsorship of the National Information System for Science and Technology (NISSAT) forming part of the Department of Science and Industrial Research (DSIR), Government of India, New Delhi. DRTC has been conducting a six-week course on "Computer Applications to Library and Information Work" since 1986 Normally, two such courses are conducted during each financial year.

Libraries

Bangalore

1. Additions to the library during the year

i) Book Acquisition

350 books were added to the library by purchase; 25 books were received on gratis.

ii) Stock position

The total stock position as on 31st March 1994 is as follows :
Books - 13,168; Books on gratis - 885; Bound volumes of periodicals - 5,600; Number of periodicals titles subscribed - 246; Number of periodicals received on gratis - 20.

iii) Technical processing
About 700 books were classified and catalogued during the year. Nearly 3,800 cards were filled.

2. Circulation statistics

During the year library facilities were enjoyed by 180 readers. 118 of them availed the lending facilities. 8 visiting professors of different Units of ISI were also provided with the lending facilities. A total of about 8,500 books and periodicals (including loose issue) were circulated by the library. The inhouse use of books and periodicals were around 31,100. About 210 inter library loan transactions were registered.

The membership includes ISI staff, Research Scholar, Project Assistants, M.Stat students, M.Tech students, SDP Fellows, DRTC students, Trainees of DRTC short term computer course etc.

3. Inter library loan service

Inter library loan facilities were availed of by the Bangalore Centre Library.

4. Reprography service

Library provided 2,70,000 xerox copies to the users during academic year 1993-94.

5. Documentation service

The following publication were brought out regularly from the library : i) Bimonthly additions list of books, ii) Monthly list of current periodicals, iii) Current contents of journals, iv) List of periodicals holding annuals.

Calcutta

With the addition of 1,179 books to the stock, the total collection of the Library rose to 1,96,019. Details of the activities are given below :

1. Acquisition Unit : The Unit accessioned 1,179 books during the period under report, out of which 948 were purchased and 231 were received as gift.

2. Periodicals Unit : The Unit received 1,100 periodicals out of which 209 were recived as gift, 432 against subscription and 450 on exchange arrangement with national and international organisations. The Unit also acquired 9 new journals. 9 journals were subscribed under NBHM grant. It accessioned 153 journals and completed the technical processing of 373 journals.

3. Circulation and Stock Maintenance Unit : The Unit issued 52,737 books and journals to the users on loan and reference. The total membership of the Library was 2,614 ou of which 230 memberships were withdrawn. The total membership includes ISI staff, research scholars, project assistants, B.Stat. & M.Stat. students, ISEC trainees etc. as well as outside students and Institute members. 571 readers were given special permission to use the Library for a short period. 81 books and journals were borrowed from other libraries and 39 books and journals were loaned to other libraries under the inter-library loan arrangement.

4. Reports and Records Unit : The Unit accessioned 282 titles and processed 75 titles. 679 titles were issued to the borrowers for reference use during the period.

5. Circulating Library : The worker's circulating Library acquired 494 new title bringing the total collection to 35,238. It issued 31,126 books to the members.

6. Technical Processing Unit : The Unit classified 1,164 books and catalogued 1,179 books. In addition to the usual work of this Unit, it has undertaken the 'Construction and Developement of Information Retrieval Thesaurus on Statistical Science and its Applications' and the work is in progress.

7. Docuemntation Unit : The Unit has been issuing current contents list services to the users on the following group of subjects : (a) Statistics and Mathematics, (b) Electronics and Communication Sciences, (c) Geology, (d) Life Sciences, (e) Economics, (f) Recent addition of books to the ISI Library.

8. Reprography and Photography Unit : The Unit provided 6,46,620 xerox prints for the users during the period under report. 1,250 frames of photographs of different nature, 2,540 prints of photographic enlargements, 50 frames of lecture slides were made during the period under report. 4,27,850 pages of off-set prints were done during the period under report.

Delhi

During the period the Delhi Centre Library performed the following activities :

1. Acquisition : Due to budget constraints, only 250 new books could be purchased and added to the stock. Received 85 publications as gift from various sources. 455 sets of loose issues of periodicals duly bound has been added to the stock, thus raising the stock to 31,549 volumes. About 300 technical reports/discussion papers/reporting etc. have been received during the above period.

2. Periodicals : 223 titles of journals, both foreign as well as Indian have been approved for renewal for the year 1994-1995. In addition 24 titles of journals were received as complimentary and against exchange programme. 455 sets of loose issues of journals duly bound were added to the stock. Journals/Technical Reports have been received under the exchange programme established with different Institutions against exchange of journal *Sankhyā*.

3. Circulation : During the period April 01, 1993 to March 31, 1994, 124 members availed the lending facilities as permanent members, and 32 members availed the reference facilities as temporary members. Approximately 6,427 publications were circulated during the period among its members. Under the inter-library programme, about 56 publications were lent out to the neighbouring Institutes and libraries and 49 publications were borrowed from them for use by Delhi Centre Library members.

4. Reprographic Services : Approx. 31,643 photocopies were made during the period on the request of users of library. Reprographic facilities have also been provided to 150 researchers of other Institutes on a nominal payment of Rs.0-50p. per page.

5. Other Activities : Like every year this year too Library trainees with remuneration have been appointed. At the end of their training, each trainee will be given an experience certificate.

Computer and Statistical Services Centre

The Computer and Statistical Services Centre (CSSC) manages the central computing facility of the Institute at Calcutta. It serves about 400 users - students, research scholars and scientific workers - with the inhouse computer system VAX 8650 and SUN SPARCSTATION 1. NSSO and CSO (I-S wing), Govt. of India are also using the computational facilities available at the centre. CSSC maintains an archive of NSSO survey data for the users in the eastern region of the country. E-mail and FAX facilities are also available in the centre.

Statistical and Computational consultancy services are provided by CSSC. During the year under report the centre provided statistical and computational services to 14 users. CSSC offered a course (of one month duration) on Objected-Oriented-Programming using C++ and MS-Windows Programming. Thirtyfive persons attended the course including the M.Tech. (CS) students, Research Fellows and Faculty members of the Institute. On the request of the Director, ISI, CSSC offered a series of courses on Word Processing for the non-scientific workers of different units. Totally 139 persons attended the courses.

The centre has also started developing program packages for its users. A package has been developed for the Dean's Office which is now in use. Currently, a package is under development for the medical welfare unit.

This year the centre has also taken up two projects from outside agencies. The first one is on the development of a database of "The technical manpower available at the various academic organisations in West Bengal". The project has been given by the West Bengal Academy for Science & Technology. The

second project is on the development of a "Computerized Archaeological Information Base." This project is funded by the Deptt. of Archaeology, Govt. of West Bengal.

The staff members of CSSC also serve as the faculty of various full time courses in the Institute and guide the projects carried out by the students. The main research areas on which the workers of CSSC are involved are Database and Knowledge Base Systems, Computer Vision and Image Processing, Interconnection Network and Distributed Operating Systems, Computational Geometry and VLSI Design, Knowledge Acquisition for Image Data and some Combinatorial Applications related problems.

National Centre for Knowledge Based Computing

Funded under the KBCS programme, sponsored jointly by the Department of Electronics (DOE) and the United Nations Development Programme (UNDP), the National Centre for Knowledge Based Computing (NCKBC) in the Institute was engaged for about six years in active research and development work in the field of Pattern Recognition, Image Processing, Computer Vision and Artificial Intelligence with a view to developing knowledge based application software in these areas. It is one of the six premier research centres in India that were designated as National Centres under the KBCS programme. The year 1993-94 was the last year of the programme with sponsorship from DOE/UNDP.

Research activities of the members of the centre during 1993-94 are summarised as follows :

1. Applications of Image Processing and Pattern Recognition

(i) Printed Bangla Optical Character Recognition : The goal here is recognition of Bangla Printed characters of a single font from books and journals. For computation of statistics of character occurrence, wordlength, bigram and trigram, data are collected from newspapers and juvenile literature. Another set of data is collected from the concise Bangla dictionary. The Bangla printed script image is segmented into lines, words and characters. The simple character features are isolated, their detection methods are found and a feature based tree classifier is designed.

(ii) Coal Quality Analysis : Several statistical pattern classification and texture analysis techniques have been used to estimate the constituents of coal from microscopic image samples, in order to quantify the quality of coal samples. Geological Survey of India has been collaborating in the project.

(iii) Ferrogram Analysis : Image of ferrograms are used for analysis of machine wear in industries. An earlier database system for searching characteristic ferrographs has been upgraded to facilitate image comparison. A set of linear feature extractors have been designed to identify materials from an RGB tristimulus color space. Preprocessing techniques to neutralize intensity variation among images have been developed.

(iv) Determination of Drinking Water Quality in Public Health Application : As recommended by the WHO, the number of Escherichia coli in water is a parameter of its quality. The E. coli content in water sample is estimated by counting the number of yellow. For processing large numbers of samples, the manual counting process normally used becomes rather tedious and error-prone. Three different methods based on skeletonization, morphological transforms and fuzzy clustering have been tested. The results obtained agree well with diagnosis by human experts.

(v) Classification of Ground Cover Types from Satellite Imagery : An attempt has been made to relate pixel groups in satellite images with actual earth surface cover types e.g., vegetation, soil water, urban area etc. A supervised classifier has been designed using statistical (Gaussian) mixture models. Learning of parameters is done on the basis an iterative method.

2. Theoretical Research in Image Processing and Pattern Recognition

(i) Fractal mathematics and its application in (a) texture analysis and segmentation and (b) data compression.

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(ii)   Artificial neural networks and genetic algorithms and their applications in shape analysis, computer vision and learning.

(iii)   Shape analysis and recognition in 2 and 3 dimensions.

(iv)   Mathematical morphology and its applications in shape analysis.

(v)   Digital topology.

4. EXTERNALLY FUNDED PROJECTS

A.   Ongoing Projects :

1.   Name of the Project : Refresher course in Statistics for under-graduate teachers of various
     universities and Colleges.
     Project Leader (s) : Y.R.K. Sarma and G.M. Saha.
     Unit involved : Stat-Math, Calcutta.
     Funded by : University Grant Commission.

2.   Name of the Project : Socio-economic survey of the sericulturist
     Name of the Project Leader : T. Maitra.
     Unit involved : Computer Science.
     Funded by : Central Silk Board. .

3.   Name of the Project : Data compression and automatic feature extraction form remotely sensed data
     and topographic maps.
     Name of the Project Leader : B.B. Chaudhuri.
     Unit involved : Electronics and Communication Sciences.
     Funded by : ADRIN, Department of Space, Hyderabad.

4.   Name of the Project : Computer application for recognition and interpretation of acoustic rader
     imageries.
     Name of the Project Leader : J. Das
     Unit involved : Electronics and Communication Sciences. .
     Funded by : DST, New Delhi.

5.   Name of the Project : Structure metamorphism, anatexis and magmatism approach for the northern
     boundary of the Eastern Ghats mobile belt around Rengali, Orissa.
     Name of the Project Leader : Samarendra Bhattacharya.
     Unit involved : Geological Studies.
     Funded By : The Department of Science & Technology, Govt. of India.

6.   Name of the Project : A neuro-fuzzy image recognition system : methodology development for
     forensic applications.
     Name of the Project Leader : S.K. Pal
     Unit involved : Machine Intelligence.
     Funded by : CSIR, New Delhi.

7.   Name of the Project : Neuro-fuzzy expert system : design and Implementation.
     Name of the Project Leader : S.K. Pal
     Unit involved : Machine Intelligence.
     Funded by : Jawaharlal Nehru Memorial Fund.

8.   Name of the Project : Development of software package - handling uncertainties for machine
     interpretation of Ill-defined structures present in gray-level images.
     Name of the Project Leader : S.K. Pal
     Unit involved : Machine Intelligence.
     Funded by : Defence Electronics Applications Laboratory, Dehradun.

9.   Name of the Project : Genetics of quantitative traits of commercial importance in the silkworm.
     Name of the Project Leader : Partha Pratim Majumder.
     Unit involved : Anthropometry and Human Genetics.
     Funded by : Central Silk Board and Department of Biotechnology.

10. Name of the Project : Improvement of health and economic status of two communities by intervention programme using leaf concentrate (LC).
Name of the Project Leader : S. Matai.
Unit involved : Leaf Protein.
Funded By : Find Your Feet (FYF), London.

11. Name of the project : "India's export to EC : constraints and prospects".
Project Leader : A. Sarma.
Unit involved : Planning (Delhi).
Funded by : International Developement Research Centre, Otwa, Canada.

12. Name of the Project : Attainment level of students at the end of Class IV.
Name of the Project Coordinator : Samir Guha Roy.
Unit involved : Psychometry Research & Services.
Funded By : Govt. of West Bengal.

13. Name of the Project : Guidance and consultancy services in data processing.
Name of the Project Leader : Prafulla Chakrabarti.
Unit involved : Sociological Research .
Funded By : Indian Council of Social Science Research(ICSSR), New Delhi.

14. Name of the Project : Study of the socio-economic impact of total literacy campaign (TLC).
Name of the Project Leaders : Samir Guha Roy and Atis Dasgupta,
Unit involved : Sociological Research.
Funded By : Department of Mass Education, Govt. of West Bengal.

15. Name of the project : Short term training programme on computer applications to library and information work.
Project Leader : M.A. Gopinath.
Unit iinvolved : DRTC (Bangalore).
Funded by : National Information Systems for science and Technology (NISSAT), CSIR.

16. Name of the Project : Fifth generation computer system and knowledge based computing systems (FGCS/KBCS).
Project Leader : B.B. Chaudhuri.
Unit involved : National Centre for Knowledge Based Computing.
Funded by : Department of Electronics, Government of India and UNDP.

B. Completed Projects :

1. Name of the project : Determination of survival, growth and reproduction rates of fresh water Indian carps with particular reference to bundh-bred, hatchery and riverine.
Name of the project leader : T.K. Basu.
Unit involved : Biometry Research.
Funded by : Directorate of Fisheries, Government of West Bengal.

2. Name of the project : Procedures for spectral characterization .
Name of the Project Leader : Swapan Kr, Parui.
Unit involved : Electronics and Communication Sciences.
Funded by : Defence Electronics Applications Lab (Deradun).

3. Name of the Project : Studies of the tropical boundary layer mateorology at Banaras using sodar and tower data (National MONTBLEX Programme).
Name of the Project Leader : J. Das.
Unit involved : Electronics and Communication Sciences.
Funded by : DST, New Delhi.

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4.   Name of the Project : Differential impact study of modern rice technology across production environments (jointly with Kalyani University)
     Principal Investigator : Sudhin Mukherjee
     Co-ordinator of ISI team : Roma Chowdhury
     Units involved : Computer Science, Computer and Statistical Service, Economic Research, Population Studies and Stat-Math.
     Funded by : Rockefeller Foundation, USA.

5.   Name of the Project : Perception, performance and potential of development in usri watershed area of Bihar plateau region : An Ecosystems Approach.
     Name of the Project Leader : Ashok Maity, Dipak Bagchi.
     Unit involved : Agricultural Science.
     Funded By : Indian Council of Social Science Research, New Delhi.

6.   Name of the project : Industrial sickness in India.
     Project leader : O. Goswami..
     Unit involved : Planning (Delhi).
     Funded by : Ministry of Industry, Govt. of India.

7.   Name of the Project : Evaluation of rainfed farming project in Eastern plateau areas.
     Name of the Project Leader(s) : Atis Dasgupta (from October 1993)/C. Dattagupta (until September, 1993)
     Unit involved : Sociological Research and Agricultural Sciences.
     Funded By : Overseas Development Administration, U.K.

5. SYMPOSIA, CONFERENCES, WORKSHOPS, LECTURES AND SEMINARS ORGANISED

The Symposia, Conferences, Workshops, Lectures and Seminars organised by the Institute during the year 1993-94 are mentioned below.

Symposia, Conferences, Workshops

A Winter School on Logic Programming and Related Topics was held at Stat-Math Unit, Calcutta during January 3-21, 1994. This was organised by K. Sikdar in collaboration with TIFR, IISc, IIT Bombay with partial support from NBHM, CSIR and DST. There were 19 registered participants including University lecturers, and Research Fellows from all over India and a few others audited the talks.

A Workshop on "Reliability and Survival Analysis" was held at Computer Science Unit, Calcutta during February 28 to March 4, 1994, organised by D. Sengupta and A. Dewanji. Twenty nine participants from different parts of India attended the Workshop.

An International Conference entitled VLSI Design, 1994 was held in Calcutta during January 5-8, 1994. Electronics Unit of ISI was one of the co-organizers of this Conference along with other organizations including VSI, IEEE, DOE, IIT Kharagpur and CMC.

A five-day Workshop on Neuro-Computing, Pattern Recognition And Computer Vision was jointly organised by the Machine Intelligence Unit of ISI and Electronics Research and Development Centre (ER & DC), Calcutta at Taratala, Calcutta from December 6 to 10, 1993. The course Director was S. K. Pal. The speakers from ISI include S.K. Pal, M.K. Kundu, N.R. Pal, C.A. Murthy, A. Ghosh, J. Basak, S.N. Biswas and D. Dutta Majumder. The participants were from various Government Organisations, Research Institutions and Industrial Organisations. B.L.S. Prakasa Rao, Director gave away the certificates to the participants at the valedictory session.

A group discussion on "Gender and Decision Making" was held on November 9, 1993 organized by Biochemistry Unit in collaboration with Psychometry and other Units of the Institute. This was organized to asses the current Indian status on the subject matter which is important for the potential collaborative study with the University of East Anglia (UEA), U.K. Major participants and discussants were from ISI, Calcutta, UEA, U.K. and investigators from various Universities and Institutes in and out of Calcutta.

The Economic Analysis Unit organized in collaboration with Indian Statistical Institute (Karnataka Branch) an open public discussion and review of "1994-95 Budget" at Woodlands Hotel, Bangalore on 11 March, 1994. T.R. Satish Chandran, former Chief Secretary, Government of Karnataka, Indira Rajaraman, Professor, Indian Institute of Management (IIM), Bangalore, Prasanna Chandra, IIM, Bangalore & former Member of Malhotra Committee and P.S. Jawadekar, Exec. Vice President, Kirloskar Electric Co. Ltd. Bangalore were the main speakers along with many others.

The DRTC (Bangalore) Unit organized a Workshop on "Artificial Intelligence Application to Library and Information Work" on 26 May to 28 May, 1993 as part of its regular academic programme. A.R.D. Prasad presided over the Workshop. 12 participants attended the Workshop. A Seminar on "Library Networks in India" was organised by DRTC (Bangalore) during 12-13 August, 1993. This Seminar organised by I.K. Ravichandra Rao. 68 participants attended the Seminar. A special Seminar on "Multi lingual Thesaurus was organised at DRTC (Bangalore) on 3 December, 1993. The lead presentation was given by Visiting Professor, Steve Pollitt from U.K. It was attended by several delegates who attended the International Seminar INFOTEX 93 held during 28 November - 2 December, 1993.

An Industrial Meet on Applications of Image Processing jointly sponsored by Computer Society of India, Calcutta Chapter and National Centre for Knowledge Based Computing Centre was organized in ISI on 21 APRIL, 1993.

Lectures and Seminars

Lectures/Seminars organised by the Institute and delivered by outside members and Visiting Professors are given below :

Theoretical Statistics and Mathematics Division

Calcutta Unit

Basu Parantap, Fordham University, USA (5.8.93) : A martingale theory of asset pricing.

Bhattacharya R.N., Indiana University, USA (7.1.94) : Random perturbations of dynamical systems starting on 7 January 1994.

Biswas Indranil, TIFR, Bombay (8.10.93) : Vector bundles on Riemann surfaces.

Bose Sudip, George Washington University, USA (17.6.93) : Robustness to the Prior : neighbourhood classes.

Bose Sudip, George Washington University, USA (18.6.93) : The association in time of a finite state semi-Markov process.

Dasgupta Aniruddha, Pennsylvania State University, USA (27.12.93) : Repeated games with asymptotically finite horizons.

Deshpande M.N., Institute of Statistics, Aurangabad (8.11.93) : A family of Hartley-Ross type estimators.

Dharmadhikari A.D., University of Poona (15.6.93 and 18.6.93) : Two sample tests based on cumulative incidence functions from coherent systems.

Dutta Somnath, University of Georgia, USA (20.12.93) : Point processes, bootstrap and inference for positive autoregressions.

Guerrd F., University of Rome, Italy (6.1.94) : The Carlen Process - Diffusions with singular drift fields.

Kawaguchi T., Japan (2.7.93) : Parameter spaces constructed by joint probability density functions and their applications.

Kundu Subiman, IIT Delhi (5.7.93) : Equality of spaces of tight measures and of measures with compact support.

Majumdar Suman, University of California at Santa Barbara, USA (23.8.93) : Weak convergence of posterior mean in mixture and product of Gaussian shift experiments.

Mandal Satya, University of Kansas, USA(4.1.94) : Sections of projective modules and divisibility in $K_0 X$.

Mukhopadhyay N., University of Connecticut, USA (27.5.93) : Sequential estimation of the mean of an exponential distribution via replicated piecewise stopping number.

Mukhopadhyay N., University of Connecticut, USA (27.5.93) : Sequential analogue of the Behrens Fisher problem.

Pattanayak S., Sambalpur University (27.5.93) : Toeplitz operators and their Predholm indices.

Puntanen Simo, University of Tampere, Finland (6.12.93) : Matrix tricks for Regression Diagnostics.

Ramamoorthy R.V., Michigan State University, USA (22.2.94) : Capacities in Statistics.

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Rao Vemuganti R., University of Baltimore, USA (17.9.93) : Logistic Problems.

Sengupta J., TIFR, Bombay (13.4.93) : Simplectic Geometry and representation of semi-simple Lie groups.

Shah Riddhi, TIFR, Bombay (15.7.93) : Limits of commutative triangular systems on real and p-adic groups.

Yanagawa T., Kyushu University, Japan (10.12.93) : Projection methods for Mantel-Haenszel estimators in 2 x J tables.

Delhi Unit

Bagchi A., University of Twente ENSCHEDE, Netherlands, (17.11.93) : Smoothing for nonlinear Elliptic boundary value processes.

Chakravarti R.S., Cochin University, (18.8.93) : Noncommutative Noetherian Rings and localisation.

Gnana Bhaskaar T. IIT, Kanpur (21.9.93) : Differential Operators with interfaces.

Gupta V.K., IASRI, Delhi, (8.9.93) : Use of combinatorics in unequal probability sampling.

Hislop P., University of Kentucky (2.9.93) : Spectral properties of hyperbolic manifolds.

Isozaki H., Osaka University, (7.9.93) : Introduction to limiting absorption principle.

Jensen A., Institute of Electronic Systems, Denmark (2.9.93) : L_p estimates for Schrodinger Operators.

Kosman-Schwarzbach Y., University of Lille, France (3.9.93) : R - Matrices and the Young - Baxter equations.

Kundu Debasis, IIT, Kanpur (14.12.93 and 15.12.93) : Statistical methods to estimate signal processing models (1) Direct approach (2) Indirect approach.

Kundu S., IIT, Delhi (24.8.93) : The equality of the spaces of tight and compactly supported measures.

Kshirsagar A.M., University of Michigan, USA (6.1.94) : A new measure of rotatability in response surface designs.

Mardia K.V., University of Leeds, UK (12.1.94) : Shape, statistics and images.

Meester Ronald, University of Utrecht (15.9.93) :1 - dependent processes and k-block factors.

Mohari A., ICTP, Trieste (18.11.93) : Markov Cocyles.

Murty V. Kumar, University of Toronto (6.8.93) : Fermat's last theorem is now a theorem.

Murty M. Ram, McGill University (16.9.93 and 17.9.93) : Fermat's Last theorem.

Puntanen Simo, University of Tampere, Finland (1.12.93) : On some matrix versions of the Cauchy-Schwarz and Kantorovich inequalities.

Raghunathan M.S., TIFR, Bombay (5.10.93) : Betti Numbers of manifolds with constant negative curvature

Shah, K.R., University of Waterloo (3.3.94) : Choice of optimality criteria.

Shah, K.R., University of Waterloo (17.3.94) : Trend-free designs.

Singh, Balwant., TIFR, Bombay (23.11.93) : The Jacobian problem.

Sridhar, R., Indira Gandhi Inst. for Devt. Research, Bombay (4.11.93) : Completely mixed games and linear complementarity problems.

Srinivas V., TIFR, Bombay (29.9.93) : On the Hodge type of projective varieties defined by equations of low degrees.

Bangalore Unit

Aravinda, G., TIFR, Bombay (11.11.93) : Rank 1 aspherical manifolds.

Athreya, K.B., IOWA State University, Ames, USA (30.6.93) : Iterations of functions : random and nonrandom.

Athreya, K.B., IOWA State University, Ames, USA, (12.1.94) : Statistical Inference for Heavy-tailed Distributions.

Balagangadharan, K., TFIR, Bombay (20.5.93) : Riemann's Memoir on the representation of a function by Trigonometric Series.

Chakravarti, R.S., Cochin University of Science and Technology, Cochin (27.5.93) : Localisation in non-commutative noetherian rings.

Chandru, Vijay, IISc., Bangalore (17.2.94) : Linear programming and the design of discrete neural networks.

Chanlilo Sagun, Rutgers University, N.J., USA (21.1.94) : On the diameter of rotating stars.

Dani, S.G., TIFR, Bombay (2.9.93) : Measure - type on lie groups.

Krishnamoorthy, A., Cochin University of Science and Technology, Cochin (22.6.93) : Multi-commodity inventory system.

Mathews, Hans V., SPIC Science Foundation, Madras (23.9.93) : Cellular twisted products.

Mukhi, Suni, TIFR, Bombay (26.11.93) : Who ordered Mathematical Physics.

Raman, S. Ganapathi, TIFR, Bangalore (9.12.93) : Asymptotic properties of eigenvalues of certain integral operators.

Sastry, Swati, Institute of Math. Science, Madras (14.9.93) : Picard's theorem and Rictman's theorem via Harnack inequality.

Sofi, M.A., TIFR, Bangalore (10.2.94) : Certain operator theoretic aspects in the geometry of Banach Spaces.

Thatte, B.D., Department of Mathematics, IISc, Bangalore (13.5.93) : Graph reconstruction problems.

Wildberger, Norman., School of Mathematics, University of Newsouth Wales (22.4.93) : Geometric quantization, representation theory and the moment map.

Yogananda, C.S., IISc., Bangalore (16.9.93) : Elliptic curves and Fermat's last theorem.

Applied Statistics, Surveys and Computing Division

Computer Science Unit

Banerjee, Anurag, CORE, University Cathlique des Louvain, Belgium (17.8.93) : Average derivative estimate.

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Basu, A.P., University of Missouri, USA (18.1.94) : Bayesian estimation of reliability for complex systems.

Chari, Manoj., Luisiana State University, USA (17.6.93) : Enumeration problems in matroids and graphs.

Deshpande, J.V., University of Poona, Pune (1.3.94) : Estimation after selection.

Ghosh Subir., University of California, USA (12.1.94) : Statistical designs and analysis of experiments : new direction in application.

Ghosh Subir., University of California, USA (13.1.94) : Efficient composite designs with small number of runs.

Kundu, Debasis, IIT, Kanpur (27.7.93) : Estimating parameters of exponential signals : A review.

Kushary Debasis., Rutgers University, USA (21.9.93) : Adaptive and unbaised predictors in a change point regression models.

Mukherjee, Jayanti., Miles Canada Inc, Canada (25.1.94) : The Role of the Biostatistician in clinical research.

Mukherjee, Rahul., IIM, Calcutta (12.10.93) : On the existence of saturated asymmetrical orthogonal arrays.

Nayak, K. Tapan., George Washington University, USA (6.1.94) : On the theory and comparison of randomised response surveys.

Sarkar, Abhinanda., Stanford University, USA (7.9.93) : On missing data, ignorability and sufficiency.

Sarkar, Palash., Computer Maintenance Corporation, Calcutta (28.9.93) : Some results on two combinatorial problems.

Sinha, Debajyoti., University of New Hampshire, USA (11.1.94) : Semiparametric Bayesian analysis of event time data.

Physical and Earth Sciences Division

Electronics Unit

Das, Sajal Kumar, Dept. of Computer Science, University of North Texas, Denton, USA (17.3.94) : Parentheses matching as a strategy for designing efficient parallel algorithms.

Dey, Tamal Kumar, Dept. of Computer Science, IUPUI, Indianapolis, USA(25.6.93) : Counting crossing traingles and halving planes.

Ghosh, Kanad, Dept. of Computer Science, State University of New York, Binghamton, USA(12.1.94) : Using WDM optical fibre interconnection for distributed shared memory multiprocessing.

Jaekel, Arunita, Dept. of Computer Science, University of Windsor, Canada (4.1.94) : Layout influenced factorization of boolean functions.

Roy, Rabindra Kumar, C & C Research Lab, NEC, Princeton, NJ, USA (11.1.94) : Optimal parallel scan during behavioral synthesis.

Srimani, Pradip Kumar, Dept. of Computer Science, Colorado State University, Fort Collins, USA (24.12.93) : Arrangement graphs as interconnection networks.

Sur-Kolay Susmita, Dept. of Computer Science, Jadavpur University, Calcutta (28.9.93) : On different complexity classes (part I).

Sur-Kolay Susmita, Dept. of Computer Science, Jadavpur University, Calcutta (5.10.93) : On different complexity classes (part II).

Sur-Kolay Susmita, Dept. of Computer Science, Jadavpur University, Calcutta (24.11.93) : On different complexity classes (part III).

Physics and Applied Mathematics Unit

Evans, D.V., University of Bristol, UK (10.1.94 and 11.1.94) : Water waves.

Guerra, F., University of Rome, Italy (7.1.94) : (a) Stochastic quantization, (b) Spin glass.

Parson, L., University of Trondheim, Norway, (14.11.93 and 7.12.93) : Two-phase flows and problems of turbulence.

Penrose, Roger, Oxford University, UK, (3.1.94) : Twistor Geometry.

Subbata, V. De., University of Bologna., Italy : Torsion and curvature.

Social Sciences Division

Economic Research Unit

Bagchi Amiya, Centre for Studies in Social Sciences (7.3.93) : The central budget : 1994-95.

Bhattacharya, Dhiresh, Calcutta University, Retd. (7.9.93) : The central budget : 1994-95.

Chakrabarti, Santi, Govt. of Kenya (20.9.93) : Some results from a macro model.

Datta-Chaudhuri, Tamal, Industrial Reconstruction Bank of India (30.9.93) : Industrial sickness and corporate restructuring.

Krishnan, T.N., CDS, Trivandrum (6.4.93) : An indirect estimate of foreign remittances.

Marjit, Sugata, Jadavpur University (12.1.94) : GATT Dunkel proposals : implications for India.

Naastepad, C.W.M., Erasmus University, Rotterdam (10.3.94) : Macroeconomic effects of the Government's financing pattern : A model for India.

Roy, Aloke, IIM, Calcutta (12.194) : GATT Dunkel proposals : implications for India.

Sengupta, Ramprasad, Jawaharlal Nehru University, New Delhi (31.12.93) : Economics of natural resources and environment - some analytical policy issues.

Storm, Servaas, Erasmus University, Rotterdam (10.3.94) : Domestic constraints on export-led growth - a case study of India.

Economic Analysis Unit (Bangalore)

Tendulkar, Suresh D., Delhi School of Economics (15.1.93) : Current situation of Indian economy : structural reforms.

Library, Documentation And Information Sciences Division

DRTC (Bangalore)

Parameswaran, M., Head, Dept. of Lib. & Sc., University of Calicut : Five laws of library catalogue.

Parthasarathy, S , Honorary Directory, Institute of Information Studies, Madras (26 7 93)   Knowledge and Skill Required for future information professionals

Neelamegham, A., DRTC Honorary Professor (22.7.93)   Quality in information resources management .

6. PUBLICATIONS

Sankhyā

Professor Prasanta Chandra Mahalanobis founded *Sankhyā*, the Indian Journal of Statistics in 1933 and he was the Founder-Editor during 1933-1972. Since its inception, eminent scholars from all over the world have contributed articles for publication in *Sankhyā*. This prestigious and internationally renowned journal is now published bi-monthly in two series, one on Probability and Mathematical Statistics and the other on Statistical Methodology and Applications, including Sample Surveys and Quantitative Economics. The Editorial Board was reconstituted during the year.

Editorial Board of *Sankhyā* Series A and B

Editors : Somesh DasGupta, G. Kallianpur, K.R. Parthasarathy, B.L.S. Prakasa Rao, C.R. Rao.

Co-Editors : Series A : Arup Bose, Probal Chaudhuri, Mohan Delampady, R.L. Karandikar, Bimal Kumar Sinha.

Series B : Probal Chaudhuri, Dipankar Coondoo, S.R. Mohan, T.J. Rao, Bikash Kumar Sinha.

Managing Editors : Series A : R.L. Karandikar.

Series B : T.J. Rao.

The following issues of *Sankhya* were released during the year 1993-94

Series A, Volume 55, Parts 1, 2 and 3; Volume 56, Part 1

Series B, Volume 55, Parts 1, 2 and 3

Other Publication

Volume 55, Part 3 of both Series A and Series B of *Sankhyā* have been published as special issues in memory of late Professor P.C. Mahalanobis on the occasion of his Birth Centenary.

7. SCIENTIFIC PAPERS AND PUBLICATIONS

Books Published

Theoretical Statistics & Mathematics Division

Delhi Unit

Cambins, S., Ghosh, J.K., Karandikar, R.L. and Sen, P.K. (Eds.) : *Stochastic Processes (Festschrift in honour of G. Kallianpur)*, Springer-Verlag, 1993.

Bangalore Unit

Thangavelu, S. : *Lectures on Hermite and Laguerre expansions*, Math. Notes, 42, Princeton University Press, Princeton, 1993.

Physical & Earth Sciences Division

Electronics & Communication Sciences Unit

Chaudhuri, B. B. and Dutta Majumder, D.: *Two Tone Image Processing and Recognition*, Wiley Eastern, New Delhi, 1993.

Biological Sciences Division

Anthropometry and Human Genetics Unit

Danda, A.K., Basu, Am. and Basu, Ar. (Eds.) : *Frontiers of Research in Anthropology*. Indian Anthropological Society, Calcutta, 1993.

Majumder Partha P. (Ed): *Human Population Genetics : A Centennial Tribute to J.B.S. Haldane*, Plenum Press, New York, 1993.

Biochemistry Unit

Chattopadhyay, M.: *Occupational Socialization : A Study of Hospital Nurses*, Sarat Book House, Calcutta, 1993.

Social Sciences Division

Economic Research Unit

Bhattacharya, N. and Coondoo, D. : *Collection and Analysis of Survey Data on Income and Expenditure : Training Handbook*, Statistical Institute for Asia and the Pacific, Tokyo, iv + 219, 1992.

Ray, B. (ed.) : *West Bengal Today - A Fresh Look*, Mittal, New Delhi, 400, 1993.

Sociological Research Unit

Dasgupta, Atis : *Sankater Mukhe Bharater Dharmanirapekshata*, (Bengali translation of The threats to Indian Secularism by Prof. Amartya Sen, Nehru Lecture delivered at Cambridge University in 1993), Nodal Research Centre, Calcutta 1994

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Malti, Asok : Development : Undone, done and not done (a study of Bihar villages), *People's Institute of Development and Training, New Delhi.*

Papers published in journals

Theoretical Statistics & Mathematics Division

Calcutta Unit

Banerjee, Soumitra and Banerjee, Pradipta : A new performance index for parameter selection under random load changes, *Electric Power System Research,* 27, 169-172, 1993.

Bhandari S.K. and Ali, Masoom N. : An asymptotically minimax procedure for selecting the *t* best multinomial cells, *J.S.P.I.,* 38, 65-74, 1993.

Bhandari, S.K., Randa, S.H. and Ali, M.M. : An optimal sequential procedure for ranking pairwise compared treatments, *CSA Bulletin,* 43, 191-197, 1993.

Bose, Arup and Chaudhuri, Probal : On the dispersion of the multivariate median, *Ann. Inst. Stat. Math.,* 45(3), 541-550, 1993.

Bose, Arup and Dasgupta, Ratan : Speed of convergence of the least squares estimator in autoregressive models, *J. Stat. Plann. and Inf.,* 38(3), 371-380, 1993.

Chandra, T.K. and Bose, A. : Cesaro uniform integrability and the L^p-convergence, *Sankhyā,* Ser. A, 55, 12-28, 1993.

Chatterjee, A.K., Bandyopadhyay, Suraj, and Rao, A.R. : Relative importance of different factors for boundary of reciprocity : An illustration, *Connections,* 16, nos. 1 & 2, 15-22, 1993.

Chaudhuri, Probal and Mikland, Per : Non-linear experiments : Optimal design and inference based on likelihood, *Jour. Amer. Stat. Assoc.,* 88(2), 538-546, 1993.

Chaudhuri Probal and Sengupta, Debapriya : A note on robust estimation of location, *Stat. and Prob letters,* 18(3), 241-244, 1993.

Chaudhuri Probal and Sengupta Debapriya : Sign tests in multidimension inference based on the geometry of the data cloud, *J., Amer. Stat. Assoc.,* 88(4), 1363-1370, 1993.

Chaudhuri Probal, Huang, Min Ching, Loh Wei Yin and Yao Ruji : Piecewise polynomial regression trees, *Statistica Sinica,* 4(1), 143-167, 1994.

Chaudhuri, G. : Coefficient of variation for the L-class of life distributions, *Communications in Statistics : Theory and Methods,* 22(9), 1993.

Das, Ashis : E-optimal block and row-column designs with unequal number of replicates, *Sankhyā,* Ser. B, 55, 77-90, 1993.

Das, A.K. and Tripathi, T.P. : Estimation of coefficient of variation using auxiliary information, *Aligarh J Stat.,* 12, 1992.

Dasgupta, Ratan : On the distribution of squares, *Sankhyā,* Ser. A, 55(1), 29-36, 1993.

Dasgupta, Ratan : Moment bounds for some stochastic processes, *Sankhyā,* Ser. A, 55(1), 150-152, 1993.

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Dasgupta, Ratan : On the distribution of eccentricity, *Sankhyā*, Ser. A, 55(2), 226-232, 1993.

Dasgupta, Ratan : Sharper speed of convergence to normality for some m dependent processes, *Sankhyā*, Ser. A, 55(2), 259-266, 1993.

Dasgupta, S. : On the evolution of the D Statistic of Mahalanobis, *Sankhyā*, Ser. A, 55, 442-459, 1993.

Ghosh, J. K. and Joshi, S.N. : On asymptotic distribution of generalised M-estimates, *Sankhyā*, Ser. A, 55, 312-320, 1993.

Ghosh, J.K. and Mukherjee, R. : Adjusted versus conditional likelihood : Power properties and Bartlett type adjustment, *J.R. Statist. Soc.*, B, 56, 185-188, 1994.

Kundu, S., Mc. Roy, R.A. and Raha, A.B. : Topologies between compact and uniform convergence on function spaces - II, *Real Analysis Exchange*, 18(1), 176-189, 1993.

Kundu, S. and Raha A.B. : Pseudocompactness versus first countability, *Question and Answers in General Topology*, 11, 183-191, 1993.

Rajeev, B. : On asymptotics of a class of one dimensional diffusions, *Math. Proc. Camb. Phil. Soc.*, 114, 499-506, 1993.

Sinha, B.K. and Sengupta, S. : Estimation of the probability of discovering a new category in finite population sampling, *Cal. Stat. Assoc. Bull.*, 43, 75-84, 1993.

Srivastava, S.M. and Sarbadhikari, H. : Random versions of extension theorems of Dugundji type and fixed point theorems, *Bulletino U.M.I.*, (7), 7-B, 631-642, 1993.

Delhi Unit

Balakrishnan, N. and Balasubramanian, K. : Log-concavity of probability of occurrence of exactly *r* arbitrary events, *Statist. Probab. Letters*, 16, 249-251, 1993.

Balakrishnan, N. and Balasubramanian, K. : Indicator method for a recurrence relation for order statistics, *Statist. Probab. Letters*, 14, 67-69, 1992.

Balakrishnan, N. and Balasubramanian, K. : Equivalence of Hartley-David-Gumbel and Papathanasio bounds and some further remarks, *Statist. Probab. Letters*, 16, 39-41, 1993.

Balakrishnan, N. and Balasubramanian, K. : Duality principle in order statistics, *J. Roy. Statist. Soc.* *Ser. B*, 55(3), 687-691, 1993.

Balakrishnan, N., Balasubramanian, K. & Govindarajulu, Z. : Relationships between moments of two related sets of order statistics and some extensions, *Ann. Instt. Statist. Maths.* 45(2), 243-247, 1993.

Balakrishnan, N., Balasubramanian, K. and Malik, H.J. : Operator methods in order statistics, *Austral. J. Statist.* 43(3), 489-496, 1992.

Balkema, A.A., De Haan, L. and Karandikar,`R.L. : The maximum of *n*-independent processes, *Appl. Prob.* 30, 66-81, 1993.

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Bhat, B.V.R. and Parthasarathy, K.R. : Kolmogorov's existence theorem for Markov processess in C^*-algebras, *Proc. Indian Acad. Sci. (Math. Sci.)*, K.G. Ramanathan Memorial Volume, 103(4), 1993.

Bhat, B.V.R. and Sinha, K.B. : A stochastic differential equation with time dependent unbounded operator coefficients, *J. Funct. Anal.*, 114, 12-31, 1993.

Bhatt, A.G. and Karandikar, R.L : Weak convergence to a Markov process : The martingale approach, *Prob. Theor. Rel. Fields.*, 96, 335-351, 1993.

Bhatt, A.G. and Karandikar, R.L. : Invariant measures and evolution equations for Markov processes characterized via martingale problems, *Ann. Prob.*, 21, 2246-2268, 1993.

Bhattacharya, Tilak : A nonexistence result for the n-Laplacian, *Pac. J. Math.*, 160(1), 1993.

Bhattacharya, Tilak and Leonetti, P. : $W^{2,2}$ regularity for weak solutions of elliptic systems with nonstandard growth, *J. Math. Anal. Appl.*, 176(1), 1993.

Bhattacharya, Tilak and Leonetti, P. : Some remarks on the regularity of minimizers of integrals with anisotropic growth, *Comment. Math. Univ. Carolinae*, 34, 597-611, 1993.

Dewan, Isha : On tests for independence in the presence of competing risks, *Sankhyā Ser. A*, 55, 104-119, 1993.

Dey, Aloke : Robustness of block designs against missing data, *Statistica Sinica*, 3, 219-231, 1993.

Fagnola, F. and Sinha, K.B. : Quantum flows with unbounded structure maps, *J. London Math. Soc.*, 48, 537-551, 1993.

Hall, P. and Roy, Rahul : On the relationship between fractal dimension and fractal index for stationary stochastic processes, *Ann. Probab.*, 21(1), 1993.

Husdon, R.L. and Parthasarathy, K.R. : Casimir chaos in a Boson Fock space, *J. Funcl. Anal.*, 119, 319-339, 1994.

Murthy, G.S.R., Parthasarathy, T. and Ravindran, G. : A copositive Q-matrix which is not R_o, *Math. Programming*, 61, 131-135, 1993.

Sengupta, D. : Decomposition of the empirical process from SRSWR into sufficient and ancillary components, *Calcutta Statist. Assoc. Bull.*, 169/170, 25-44, 1993.

Bangalore Unit

Bagchi, Sunanda, Ching-Shui Cheng : Some optimal designs of block size two, *Journal of Statistical Planning and Inference*, 37 , 245-253, 1993.

Bhat, Rajaram, Pati, V. and Sunder, V.S. : On some convex sets and their extreme points, *Mathematische Annalen*, 296, 637-648, 1993.

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