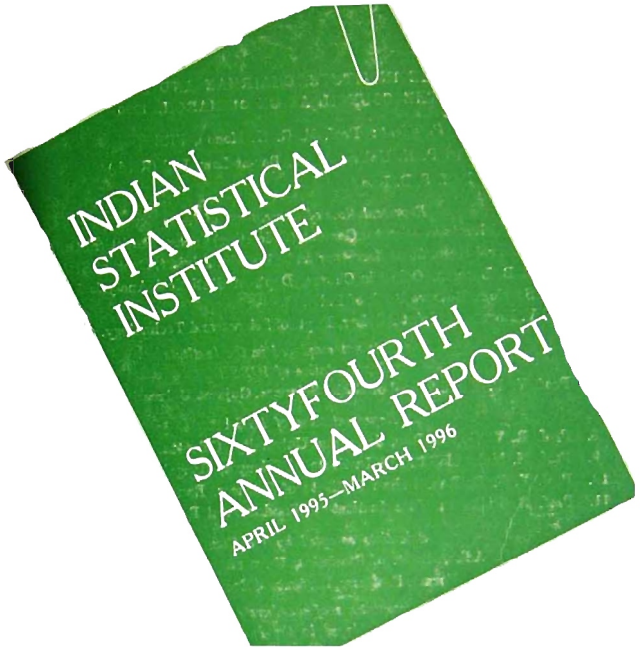

203 BARRACKPORE TRUNK ROAD
CALCUTTA · 700 035

PRESIDENT OF THE INSTITUTE, CHAIRMAN AND OTHER MEMBERS OF THE COUNCIL AS ON 31 MARCH, 1996

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

1. *Chairman* : Shri P. N. Haksar, M.Sc., Bar-at-Law, IFS (Retd.)
2. *Director* : Prof. S. B. Rao

Representatives of Government of India

3. Dr. S. S. Srivastava, Director General, (Officiating) Central Statistical Organisation.
4. Shri Kanwal Nath, Joint Secretary and Financial Adviser, Dept. of Statistics.
5. Dr. R. B. Barman, Officer in Charge, Dept. of Statistical Analysis & Computer Services, Reserve Bank of India.
6. Dr. V. Ramesam, Joint Adviser, Dept. of Science and Technology.

Scientists not employed in the Institute
Representative of ICSSR

7. Prof. V. P. Shah, School of Social Sciences, Gujarat University, Ahmedabad.

Representatives of INSA

8. Prof. R. V. Gopala Rao, Jadavpur University, Calcutta.
9. Prof. N. Mukunda, Indian Institute of Sciences, Bangalore.
10. Prof. V. S. R. Rao, Indian Institute of Sciences, Bangalore.
11. Prof. R. Sridharan, Tata Institute of Fundamental Research, Bombay.

Scientists co-opted by the Council

12. Prof. S. R. Adke, Dept. of Statistics, University of Pune, Pune.
13. Prof. Asish Bose, Former Professor, Institute of Economic Growth, Delhi University.

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

14. Prof. Deb Kumar Bose, Chairman, West Bengal Pollution Control Board.
15. Prof. Prabuddha Nath Roy, Pro-Vice-Chancellor (Academic), Calcutta University.

Elected representatives of the employees of the Institute

16. Shri Dilip Sengupta, Representative of the Scientific Workers.
17. Shri Sashi Kanta Mishra, Representative of the Non-Scientific Workers.

Officers of the Institute

18. Prof. B. V. Rao, Professor-in-Charge, Theoretical Statistics and Mathematics Division.
19. Shri C. H. Sastry, Professor-in-Charge, Applied Statistics, Surveys and Computing Division.
20. Prof. D. Coondoo, Professor-in-Charge, Social Sciences Division.
21. Prof. Raj Kumar Roychowdhury, Professor-in-Charge, Physical and Earth Sciences Division.
22. Prof. Partha Pratim Majumder, Professor-in-Charge, Biological Sciences Division.
23. Shri. B. K. Pal, Head, Statistical Quality Control and Operations Research Division.
24. Dr. Joseph Mathew, Dean of Studies.
25. Prof. Atul Sarma, Head, Delhi Centre.

Non-Member Secretary

Shri G. H. Mandal, Chief Administrative Officer.

INDIAN STATISTICAL INSTITUTE

Annual Report

April 1995 - March 1996

203 Barrackpore Trunk Road
Calcutta 700035

INDIAN STATISTICAL INSTITUTE
SIXTYFOURTH ANNUAL REPORT
April 1995 - March 1996

CONTENTS

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 the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists 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. In addition it has a network of service units of Statistical Quality Control and Operations Research Division at Baroda, Bombay, Trivandrum, Pune, Coimbatore, Madras, Hyderabad, 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 which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale 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) was started for conducting socio-economic surveys of all-India coverage on a continuing basis. This was the first ever attempt in India to have a data base for various developmental programmes and the five year plans. The ISI group on sample surveys served as the Technical Wing of the NSS from 1950 till it was transferred to the Government of India in 1972.

The ISI was first again to play 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 Indian 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 named, *Barapasaurus tagoreii*, from the lower Jurassic Kota rocks near Sironcha, Gadchiroli district, Maharashtra, in the sixties. The discovery 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.

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 the International Statistical Education Centre (ISEC), Calcutta, jointly with ISI, to impart training in Theoretical

and Applied Statistics to participants selected from developing countries. The centre is run by ISI jointly under the auspices of UNESCO, International Statistical Institute and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater 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.

In keeping with the changes over time, the Memorandum of Association of ISI has been updated in 1976.

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 the bottom 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 Fast Fourier Transform (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), 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 programmes. In economics, the Institute has come to be known as a specialized 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 for the hearing impaired children, developed by Prof. Kostic. 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 differing environments, human ecology and growth and genetic epidemiology.

Depletion of technical personnel with collection and analysis of field data has adversely affected empirical research in the Institute. Moreover, the dearth of the faculty members in Certain Science Units has created the problem of optimum expansion of scientific activities of the Institute.

Over the years, the SQC & OR Division has grown to the size of having ten operating units all over the country and have uniquely served for promotion, education and training and technical guidance in Total Quality Management 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 areas 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. Computerization of library facilities has been taken up which will certainly enhance the facilities for the users. Much more is on the anvil in this direction.

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 documentation and information science. The Institute awards post-graduate diplomas in documentation sciences.

An index of the contributions of the Institute is the publication of many books and monographs, in addition to a large number 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.

Director's Report

During the year, training in core areas of Statistics, Mathematics, Economics, Computer Science and other related fields was in full gear. The scientific and technical workers kept a busy schedule with research activities, project works, case studies both in theoretical and applied statistics as well as in other interdisciplinary areas. An adaptive transformation and retransformation technique was developed that turned out to be quite useful in robust and efficient analysis of spatio-temporal data arising from bio-medical sciences. A problem of current research interest in Survey Sampling relates to subdivisions (domains), of varying sizes of a population based on samples drawn from the latter. The recent trend in the country towards decentralised administration has given rise to increasing demands for small domain statistics. The Institute embarked on new methods in this area to suit Indian data. Many new techniques are emerging to tackle this small domain statistics, making use of Bayesian principles, variance components analysis, Kalman filtering and others. Hardy's Theorem for certain liegroups which can be considered as study of 'uncertainty principle' on certain liegroups and manifolds has been obtained. It was shown that a Banach space is Hahn-Banach Smooth in its bidual for each equivalent renaming only when it is reflexive.

A Plan and Policy Research Unit has been established under the Planning Unit at Delhi Centre with an endowment fund of Rs.2.00 crores from the Government. The unit will be working in close collaboration with the Planning Commission and will be conducting studies to aid National Policy and Planning. At the invitation of the Department of Statistics a project entitled "Poverty Assessment in India" was undertaken by the Institute. A Survey Research and Data Analysis Centre to conduct research on innovative methodologies for collection and analysis of survey data is being planned at Calcutta to work, in much more closer collaboration, with the Planning Commission, National Sample Survey Organisation, Department of Statistics and others.

We should appreciate the crucial role of statistics as a science and key technology and create conducive atmosphere for its large scale applications based on an objective, critical long cost-benefit evaluations. In this age of integral global economy, the nations can improve living standards by establishing key industries and at the same time providing quality products. The use of Statistical Quality Control and Reliability techniques in controlling loss and cost and for improving and augmenting productivity in industries has generated great impetus to the Quality Control movement in the country. The Institute with its expertise in the Quality movement in the country since 1953 is providing training and consultancy in all areas of Quality Management and Quality Systems related to ISO-9000 certification. Besides, the unit has trained Quality Mission Executives who in turn are deputed to various organisations for training and implementation of Total Quality Management and ISO-9000 techniques. It may be mentioned here that Indian exports to European Union Countries, particularly textiles and garments, leather goods and pearls individually contributed more than 10% each in the last two years. The Institute is exploring the possibility of undertaking further applications of Quality Control and Reliability consultancy in these areas especially in textiles/garments for export.

A land mark development of the Computer Vision and Pattern Recognition Unit is a computer based dictionary in the Indian language (Bangla) which may be used by the blind persons as well. A novel highly structured 3-layered basic network called X-tron has been developed by the Machine Intelligence Unit with supervised and undersupervised learning algorithm for mixed category perception. Its utility has been established in building a psychologically motivated powerful system, called PSYCOP, for simultaneous multiple recognition of industrial objects with orientation and shift variance. The model uses the concept of 'what it is' and 'where it is' as done in animated brain. The VLSI team of the Electronics Unit has developed a new CAD technique for better testability, speed, efficient floorplanning and novel routing strategies to design complex microchips and to minimize their size. All these techniques will lead to cheaper, faster, more reliable and area-efficient VLSI chips with complex inter-connection structures. The parallel processing team has proposed a novel cost-effective multi-mesh architecture for parallel processing which can be used to solve problems on Numerical Analysis, Image and Signal Processing etc. very efficiently. The Computer Science Unit is developing software packages for Directional Data Analysis useful in Atmospheric Science, Geological Studies, Oceanography, Agriculture, Image and Shape Analysis including Bio-medical Imaging etc.

The Institute also undertook several externally funded projects of National Importance from different Government and non-Government organisations. These include a knowledge based computing (CSIR), Studies on the PBL dynamics using sodar and tower data, Development of computer algorithm for recognition & interpretation of sodar patterns, A knowledge based fremework for diagnosis & therapy planning using multimodality medical imaging (DST), A neuro fuzzy image recognisation system - methodology development for forensic applications (CSIR), Development of software packages (DEAL), Genetics of quantitative traits of commercial importance in the silkworm (CSB), Molecular Epistasis and the human globin gene clusters with special reference to haemoglobinopathies in Eastern India (DBT), Evaluation of rainfed farming project (HFCL, ODA), Total literacy campaign (CMC), In depth studies on the levels of development of SC's and ST's (GOI).

In recognition of the excellent research work done by the scientists of the Institute in several areas related to statistics, the Section 4 of the Indian Statistical Institute Act of 1959 has been amended by the Parliament to empower the Institute to award Degrees/Diplomas not only in statistics but also in mathematics, quantitative economics, computer science and such other subjects related to statistics with effect from 18 September 1995. Further the Council, General Body of the Institute, the Registrar of the Societies and the Government approved changes in 29 clauses of the Regulations in the Memorandum of Association of the Institute which include creation of a new Scientific Division "Computer and Communication Sciences Division", a committee "Policy Planning and Evaluation Committee" to identify, from time to time, focal themes of research and to formulate concrete interdisciplinary proposals for major research projects pertaining to these themes, and Head of Bangalore Centre as a member of the Council of the Institute.

In appreciation and recognition of high standard of research and scientific excellence maintained by the researchers of the Institute, several faculty members and scientific workers of the Institute received laurels in the forms of awards and fellowships during the year. Professor J.K. Ghosh of the Theoretical Statistics and Mathematics Unit at Calcutta, as the President of the International Statistical Institute for the term 1993-95, conducted the International Conference of the International Statistical Institute at Beijing from August 21-29, 1995. Professor J.K. Ghosh has been offered the Jawaharlal Nehru Professorship of the Institute and Professor Ghosh accepted this offer with effect from 15 February 1996. Professor K.R. Parthasaraty of the Theoretical Statistics and Mathematics Unit at Delhi has been awarded the Sir C.V. Raman Research Professorship of the INSA. Professor K.R. Parthasarathy also delivered the G.H. Hardy lectures organised by the London Mathematical Society in the summer of 1995. Professor R. Bhatia of the Theoretical Statistics and Mathematics Unit at Delhi won the S.S. Bhatnagar award of the INSA. Professor B.L.S. Prakasa Rao was the President of the Statistics Section of the 83rd Indian Science Congress held at Patiala. Professor K.B. Sinha has been elected as the vice-President of Indian Academy of Sciences. Professor Sankar Kumar Pal of the Machine Intelligence Unit has been elected as a fellow of the National Academy of Engineering and Indian Academy of Sciences. Professor Pal also received the NASA patent application award from NASA Inventions and Contribution Board, USA (jointly with L. Wang). Professor B.B. Chaudhuri of the Computer Vision and Pattern Recognition Unit has been awarded the Hari Om Prarit Vikram Sarabhai research award. Several other young faculty received Young Associate Awards, Young Scientist Awards and Fellowships from Scientific bodies such as INSA, Indian Academy of Sciences, University Grants Commission, Indian Science Congress Association etc.

It has been a practice for the Institute to share its expertise and its facilities with collegues and scientists from other institutes, universities, colleges and research organisations. Following this view, various summer/winter schools, seminars, workshops, lecture series and conferences were held during the year to disseminate new results obtained as well as to strengthen the research, project work, case studies and consultancy work, with fresh ideas. A summer school on 'Descriptive Set Theory' was organised by the Stat-Math Unit in Calcutta. A winter school on 'Group Representations and Function Theory' was held by the Stat-Math Unit of the Bangalore Centre. The Stat-Math Division organised a lecture series/workshop on "The Mathematical Heritage of Norbert Wiener" at Delhi as a centennial tribute to Norbert Wiener whose visit to the Institute in its early years had a decisive influence on the unexpected flowering of mathematical research at the Institute. A summer school on "Advanced Econometric Techniques and their Applications" was organised by the Economic Research Unit, Calcutta. The 11th annual conference on 'Economic Theory and Policy' was held at Delhi by the Planning Unit. The second workshop on "Directional Data Analysis" was held by the Computer Science Unit, Calcutta. A workshop on 'Image Processing' was conducted by Computer Vision and Pattern Recognition at Calcutta. A mammoth International Conference on "Game Theory and Economics Applications" was organised at Bangalore under the joint auspices of the Indian Institute of Science, Indian

Statistical Institute and the Jawaharlal Nehru Research Centre in which several leading experts, at least 40 from abroad and 60 from India, participated. A mammoth International Symposium on '70 years of Quantum Mechanics and Recent Trends in Theoretical Physics' was held at ISI, Calcutta, under the joint auspices of the Institute and S.N. Bose National Centre for Basic Sciences, Calcutta. A UGC refresher course in Statistics to college/university teachers/researchers was held at Calcutta. Two workshops on 'Total Quality Management' was held at Calcutta to further improve the quality of SQC and OR consultancy services of the Institute. Keeping with the current liberalisation process of the Government, the CVPR Unit conducted a collaborative programme with Pertech Computers Ltd. The second one is in progress. A team of mathematicians at Bangalore are participating in the Nurture Programme of the NBHM for Indian National Mathematics Olympiad awardees.

Regarding the teaching and training activities during the year, 8726 candidates applied for admission to various courses offered by the Institute including B.Stat.(Hons.), M.Stat. (M and S Stream), M.Tech. (Computer Science), M. Tech. (Quality, Reliability and Operations Research) etc. A total of 4952 candidates finally appeared for the admission tests and a total of 471 candidates qualified for interview for selection Based on the academic record, performance in the written tests and interviews, a total of 197 candidates were offered admission to various courses leading to degrees and diplomas during the academic session under review. The 30th Convocation of the Institute was held on 15 February 1996 and Dr. R.A. Mashelkar, DG, CSIR, delivered the convocation address - Progress Through Partnership : The Emerging Paradigm.

It was felt that the Institute needs to develop and start a M.S. Course on Quantitative Economics to meet some of the needs of the country for development of Human Resources and Research Encouraged by the recent amendment of the Indian Statistical Institute Act, it is planned to start this course from the next academic session. Recruitment of faculty based on the research needs in various disciplines is in progress.

The International Statistical Education Centre (IESC) is run by the Institute as an Associate body/institution under the Regulations of the Memorandum of Association of the Institute jointly with the International Statistical Institute under the sponsorship of the UNESCO and the government since 1950. At present the centre is conducting its forty-ninth term with ten foreign and five Indian trainees. Due to discontinuation of the fellowships by the Government of India under SCAP and ITEC programmes, representations from the African countries is continuously absent during the last two years. The Institute has approached the Government to restore these scholarships as there are requests from UN Agencies and the African Government for such a training.

Negotiations that have been going on between the Government and the Institute on revised payscales for our administrative and scientific, supporting technical staff and lifting of embargo on recruitment of workers in these categories have recently been settled favourably to the Institute. Scientists may expect better administrative and technical support in the next financial year, after recruitment of essential staff in these categories based on the assessment of the needs of the Institute, taking into consideration the changes and the new environment. This process has already started.

As far as the financial position is concerned, the Government appreciating the new mechanisms for budget control adopted by the Institute, increased the non-plan budget of the Institute so far as the salaries and other allowances are concerned, reasonably, but the amount approved under the head "non salaries items" remains the same as in the previous year. Although the plan budget for 1995-96 is less than that of 1994-95, the Government approved an additional amount of Rs.2.00 crores as an endowment fund for the Plan and Policy Research Unit at Delhi Centre.

The progress on the construction of a new Guest House at Calcutta, and construction of 'D' type quarters at Calcutta are in full swing. Additional floor space on the Academic Block at Bangalore Centre has been constructed. Residential accommodation at Pune has been bought and similar efforts are under way to buy residential flats at Bombay for furtherance and strengthening of the Quality Control and Reliability consultancy services. Internet/NIC net connection for research work are expected to be installed soon at Calcutta, Delhi and Bangalore Centre.

The Council of the Institute approved of a comprehensive scheme of medical facilities to be extended to the retired employees of the Institute. The scheme has been forwarded to the Government and is awaiting approval before implementation.

Our Institute is nationally and internationally recognised as a centre of excellence both for its theoretical contributions to Statistics and related areas, as well as applications of Statistics. We all pledge to uphold the standards and keep the banner of recognition high. In the new environment, Indian Statistical Institute has a further dynamic role to play for furtherance of its excellence in the above areas and for national development. "WORK IS WORSHIP" and "UNITY IN DIVERSITY" should be our mottos.

31 March 1996

(S.B. RAO)

1. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities during the period from April 1995 to March 1996 is given below.

During the academic session 1995-96, 8726 candidates applied for admission and were called for written selection tests for the various courses offered by the Institute, viz., 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 (Madras), Research Fellowships in Statistics, Mathematics, Economics, Computer Science and Communication Sciences, Theoretical Computer Science, Physics and Applied Mathematics, Anthropology, Geology, Demography, Sociology, and Statistical Quality Control, 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 21 different Centres all over the country. A total of 4952 candidates finally appeared for admission tests and a total of 471 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 197 candidates were offered admission to various courses during the academic session under review.

Apart from the above, for the Associateship in Documentation and Information Science (ADIS) course, candidates were chosen through an initial screening followed by an interview. Nine candidates were finally selected.

The annual examinations for all the regular courses were held in May/June 1995. The 1995-96 academic session commenced on 3 July, 1995.

The number of candidates admitted to the different degree, diploma and training courses in 1994-95 and 1995-96 and the number of students passed in the annual examinations in 1995 are given below.

Twenty-one trainees in Engineering and Technology from various Universities (Jadavpur, Calcutta, B.E. College (Deemed University), Benaras Hindu University, R.E.C. of Allahabad, Kurukshetra, Bhubaneswar and Durgapur, J.N. Technological University, Kakinada) received a six to eight week practical training in the different Computer Science Units of the Institute, viz., ECSU, EU, CVPRU, CSSC and CSU. Besides ten MCA and M.Tech. students (from IGIT, Sarang; North Bengal University; Nagarjuna University; University of College of Technology, Calcutta) did their six month project work in the above Computer Science Units of the Institute.

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

Course		Number of Students		
		Enrolled in 1994-95	Passed in the annual exam. in 1995	Enrolled in 1995-96
(1)		(2)	(3)	(4)
Degrees				
1.	Bachelor of Statistics with Honours [(B.Stat.)(Hons.)]			
	1st year	28	27	36
	2nd year	10	10	27
	3rd year	22	22	10
2.	Master of Statistics (M.Stat.)			
	1st year (M-stream)	11	10	14
	1st year (S-stream)	19	18	34
	2nd year	37	35	30
3.	M.Tech. in Computer Science			
	1st year	21	21	23
	2nd year	18	18	21
4.	M.Tech. in Quality, Reliability and Operations Research			
	1st year	14	14	18
	2nd year	14	14	14
Diploma/Certificate/ Associateships				
5.	Course on Operation and Programming of Automatic Data Processing Equipment			
	1st year	12	11	12
	2nd year	7	7	11
6.	Part-time Certificate/Diploma Course in Statistical Quality Control and Operations Research (Bombay and Madras)			
	Bombay - 1st year and 2nd year	-	-	-
	Madras - 1st year	++	++	10
	2nd year	6	4	-

++ : Course was not offered in 1994-95

	(1)	(2)	(3)	(4)
7.	Associateship in Documentation and Information Science (Bangalore)			
	1st year	12	10	11
	2nd year	9	8	10
8.	One Year Part-time Course in Statistical Methods and Applications			
	Calcutta	16	7	27
	Delhi	-	-	-
	Hyderabad	18	13*	++
9.	Six-month Part-time Course in Statistical Quality Control			
	Bangalore	33	31	++
	Hyderabad	34	22	++
10.	Intensive Course in Programming and Applications of Electronic Computers	16	15	6
11.	Junior Diploma in Statistics (Dec. 1994 and July 1995)	14	5	-
Fellowships				
12.	Junior and Senior Research Fellows, Visiting Fellows, Post-doctoral Fellows and Research Associates in different discipline	123***	15+	114**
	GRAND TOTAL	494	317	477

* Awaiting the approval of the Academic Council
++ Not available with Dean's Office
** Number of scholars as on 1 November 1995
\+ Awarded Ph.D. in the 1996 convocation
*** Number of scholars as on 1 March 1995

Ph.D. Degrees Awarded

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

i)	Sunmangali Kidambi Venkatewan	: "Discrete Singularity Method and its Applications to Incompressible Flows" Supervisor : H.P. Majumdar, ISI, Calcutta.
ii)	Indranil Biswas	: "Study of Moduli Bundles" Supervisor : S. Ramanan, TIFR, Bombay.
iii)	Debatosh Ghosh	: "Optimal Continuous Sampling Plans and a Few Other SQC Problems" Supervisor : A.C. Mukhopadhyay, ISI, Calcutta.
iv)	Swapan Kumar Nath	: "Genetic Epidemiological Analysis of Complex Disorders in Man with Special Reference to Vitiligo" Supervisor : P.P. Majumder, ISI, Calcutta.
v)	Subhashis Ghosal	: "Asymptotic Properties of Posterior Distributions and Study of Some Nonregular Cases" Supervisor : J.K. Ghosh, ISI, Calcutta.
vi)	Jayanta Basak	: "Connectionist Models for Certain Tasks Related to Object Recognition" Supervisor : Sankar K. Pal, ISI, Calcutta.
vii)	Sushmita Mitra	: "Neuro-fuzzy Models for Classification and Rule Generation" Supervisor : Sankar K. Pal, ISI, Calcutta.
viii)	Joydip Mitra	: "Model and Design Based Analysis of Complex Surveys". Supervisor : Arijit Chaudhuri, ISI, Calcutta.
ix)	Aniruddha C. Naolekar	: "Some Problems in Equivariant Topology". Supervisor : Amiya Mukherjee, ISI, Calcutta.
x)	Delampady Narayana	: "Interaction of Price and Technology in the Presence of Structural Specifications : Analysis of Crop Production in Kerala". Supervisor : A. Vaidyanathan, Inst. of Dev. Studies, Madras.
xi)	Uma Krishnan	: "Computing Squares and Principal Graphs of Subfactors". Supervisor : V.S. Sunder, ISI, Bangalore.
xii)	Rajib Kumar Das	: "Design, Analysis and Routing in Static Interconnection Networks". Supervisor : B.P. Sinha, ISI, Calcutta.
xiii)	Nirupam Sarkar	: "On Texture Image Analysis Using Geometry Based Features". Supervisor : B.B. Chaudhuri, ISI, Calcutta.

xiv)	Murari Mitra	: "On Nonparametric Families of Life Distributions : Some Issues and Applications" Supervisor : Sujit Kr. Basu, Indian Instt. of Management, Calcutta.
xv)	Anandam Ganesh Kumar	: "Stability of Cereal Crop Yields' Performance : An Econometric Analysis for India and Andhra Pradesh" Supervisor : N.S.S. Narayana, ISI, Bangalore.

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

i)	Parthasarathi Ghosh	: "Mesozoic Stratigraphy and Sedimentation in and around Jabalpur, Central India" Supervisor : D. K. Rudra, ISI, Calcutta. (Awarded by Calcutta University)
ii)	Jayasree Das Sarma	:"Development of an Enzyme Immunoassay Method for Determination of Folic-acid and its Biomedical Application". Supervisor : C. Duttagupta, ISI, Calcutta. (Awarded by Jadavpur University)
iii)	Debasish Chaudhuri	: " Some Studies on Density Estimation and Data Clustering Techniques" Supervisor : B.B. Chaudhuri, ISI, Calcutta. (Awarded by Jadavpur University)
iv)	Dyuti Prasad Dolui	: "A Study of Some Problems on Propagation and Generation of Water Waves" Supervisor : B.N. Mandal, ISI, Calcutta. (Awarded by Calcutta University)
v)	Anjana Sinha	: "Some Problems in Supersymmetric Quantum Mechanics and Quantum Field Theory in Flat and Curved Spaces" Supervisor : Rajkumar Roychoudhury, ISI, Calcutta. (Awarded by Jadavpur University)
vi)	Pratap Chandra Roy	"Some Problems on Thin Liquid Film Formation on a Rotating Disc" Supervisor : B.S. Dandapat, ISI, Calcutta. (Awarded by Calcutta University)

International Statistical Education Centre (ISEC), Calcutta

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

The Centre provides training in Theoretical and Applied Statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia, the Far East and the Commonwealth countries in Africa. Major training programmes of the Centre is a 10-month Regular Course in Statistics. In addition, Special Courses of varying durations are also organised. Facilities also exit for research work and advanced studies by senior statisticians from abroad. Since inception, the Centre has provided training 1239 trainees from 56 countries in respect of its regular courses.

A total of 26 candidates from 9 different countries were nominated by the respective governments for admission to the 49th term of the Regular Course of this Centre. Of these 26 candidates, 16 candidates were offered admission and 15 participants joined from 5 countries - Maldives, Phillippines, Srilanka, Vientiane and India. Trainees, ten in number were supported by fellowships awarded by the Government of India under the Technical Cooperation Scheme of the Colombo Plan, Aid to Sri Lanka and Aid to Maldives Schemes. Among the other 5 trainees, 2 candidates were nominees from Indian Air Force and the remaining candidates were nominated by the Ministry of Home, Government of India. All these 5 trainees were supported by their respective employees.

Teachers of Headquarters at Calcutta of the Indian Statistical Institute and Officers of the Government of India participatged in teaching the Regular Course during the year.

The Convocation of the 49th regular course of ISEC was held on 28 March, 1996. Mr. A.C. Basu, the Ex-Regional Advisor of Economic and Social Commission of Asia and the Pacific was the Guest-in-Chief on the occasion. All the Regular Course trainees were awarded Statistical training Diploma.

Besides the above, five trainees, - three from Vietnam, one from Myanmar and one from Kenya - were awarded Certificates for attending Special Courses in Statistics with emphasis on Demography, Survey Sampling and Data Processing during the period under review. These trainees were supported by fellowships from the United Nations Development Programme.

For forthcoming 50th term of the course, 13 applications were received till March, 1996 from Bhutan, Bangladesh, Maldives, Sri Lanka and Myanmar for admission.

Professional Examinations in Statistics

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

1. Statistical Assistantship Certificate
2. Junior Diploma in Statistics
3. Senior Diploma in Statistics

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

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

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

The details of the examinations for July 1995 and January 1996 terms are given below :

Examinations	Number of Candidates					
	Registered		Appeared		Passed *	
	July 1995	January 1995	July 1995	January 1995	July 1995	January 1995
1. Statistical Assistantship Certificate	10	8	7	5	5	1
2. Junior Diploma in Statistics	51	43	14	22	11	9
3. Senior Diploma in Statistics	8	13	5	7	2	1

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

Preparation for the next term Professional Examinations scheduled to be held in August, 1996 is under way. Preparation of the Model-answer booklet for the compulsory papers in Senior Diploma in Statistics is also under way.

The total number of candidates who have qualified for the award of the Certificates and Diploma in the Professional Examinations in Statistics including the result of January 1996 term are 485 and 274 respective.

2. THIRTIETH CONVOCATION

Indian Statistical Institute held its Thirtieth 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 15 February 1996.

Professor M.G.K. Menon, FRS, President of the Institute presided over the Convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor .S.B. Rao, Director of the Institute, presented annual review of teaching and training activities of the Institute. Professor R.A.Mashekar, Director-General, Council for Scientific and Industrial Research, New Delhi, delivered the Convocation address entitled "Progress Through Partnership : The Emerging Paradigm".. In his address, Professor Mashekar highlighted the partnerships between diverse disciplines of science, business and nature.

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.)	15
Master of Technology (M.Tech.) in Computer Science	20
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	14
Master of Statistics (M.Stat.)	35
Bachelor of Statistics (Honours) [B.Stat.(Hons.)]	22
Part-time Diploma in Statistical Quality Control and Operations Research, Madras	4
Diploma on Operation and Programming of Automatic Data Processing Equipment	7
Associateship in Documentation and Information Science, Bangalore	8
Professional Examinations in Statistics : Junior Diploma in Statistics	5
Total :	130

AWARDS 1995

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

Malabika Pramanik

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

B.Stat. (Hons.)	:	Siddhartha Madhav Gadgil
M.Stat.	:	Siddhartha Basu
M.Tech.(CS)	:	Samik Sengupta
M.Tech. (QROR)	:	V. Roshan Joseph

3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The major thrust of the Institute is on research in various disciplines comprising theoretical statistics and statistical methodology, Mathematics, undertaking both internal and externally funded projects in diverse fields of applications, consultancy and collaboration with several scientific organisations and industries. For academic and administrative convenience these are grouped in the Divisions listed below. It may, however, be mentioned that scientists belonging to a Division carry out independent as well as collaborative research with scientists belonging to other Divisions.

Theoretical Statistics and Mathematics Division; Applied Statistics, Surveys and Computing Division; Physical and Earth Sciences Division, Biological Sciences Division; Social Sciences Division; Statistical Quality Control and Operations Research Division; Library, Documentation and Information Sciences Division. There is also a well equipped Computer and Statistical Services Centre (CSSC) which manages the VAX system and e-mail system and provides computing and statistical analysis to researchers. This supplements to a large extent the computer facilities slowly being developed within the units for easy and quick access. The Institute is planning to have a complete network of the facilities. In view of the growth of some new disciplines, the Institute has decided to reorganise the divisions and this will be completed during the financial year 1996-97.

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

Theoretical Statistics and Mathematics Division

The Division with units at Calcutta, New Delhi, Bangalore and Hyderabad has a major role in teaching Probability, Statistics and Mathematics in the B.Stat.(Hons.), M.Stat., M.Tech. (CS), M.Tech. (QR&OR) and other courses of the Institute. The division also conducts courses for 3-4 semesters at an advanced level for research fellows enrolled for the Ph.D. degree of the Institute. The unit at Calcutta regularly conducts a weekly colloquium with speakers both from within the unit and outside. The Division regularly conducts workshops, summer/winter schools, refresher courses and conferences with extensive interaction from academics of various organizations both in India and abroad, funded by external agencies as well as by the Institute, the details of which for the year under review are given elsewhere. The research activities of the division are in probability theory, theoretical statistics, stochastic processes, mathematical and stochastic modelling, various branches of pure mathematics such as Algebra, Functional analysis, Combinatorial theory, to mention some broad areas. Several members also provide statistical consultation to other units in ISI or other organisations.

Some of the areas of research and contributions from various units are given below :

Calcutta Unit

Mathematics

1. Topology and Set Theory

Detailed study of Buchwalter's bounded-open topology in its proper perspective has been carried out.

Some equivariant problems of algebraic topology and differential topology were investigated.

Continuity of group multiplication was studied.

2. Functional Analysis

Stability of various classes of Banach spaces - spaces with the W* asymptotic norming property (ANP), Hahn-Banach smooth and nicely smooth spaces - have been studied. A new ANP has been introduced and its isometric characterisations are obtained and stability properties studied. It was shown using an elementary proof that every equivariant renorming of a space is nicely smooth if and only if it is reflexive.

Work on Harmonic analysis on Lie groups continued.

3. Graph Theory

A Markov chain simulation method for generating random (0, 1) - matrices with given marginals as well as random networks with given out-degrees and in-degrees has been developed and used for the study of social networks. Work on chordal graphs, intersection graphs, degree sequences, centres of graphs and digraphs, rectilinear graphs, spanning trees in weighted connected graphs and self-complementary graphs continued.

4. Theoretical Computer Science

Exact and approximate algorithms for hard problems and approximability have been studied including a critical cut heuristic for MAX-CUT problem.

Statistics

1. Statistical Methods

An adaptive transformation and retransformation technique for robust and efficient estimation of parameters based on high dimensional data arising in biomedical and sociological studies has been developed and successfully implemented.

Multivariate outlier detection schemes have been proposed and computer algorithms were worked and they are tried on data sets successfully.

Study of Lorenz curve of concentration is an all important concept in applied research. Now study of Lorenz curve of concentration in the bivariate case is taken up and algorithms are being developed.

Over the years the Institute has a good data base of students selected for various courses in the Institute through selection tests. Studies have been undertaken for a statistical analysis of the data for updating our system as well as suggesting any possible changes.

2. Statistical Inference

Some of the main problems on which work was carried out include

Consistency questions for posterior in infinite dimensional problems, Bayesian semiparametric problems,

Generating an event with probability g(p) where p is the Bernoulli parameter and its use in classical estimation problem,

Model based estimation in Categorical data analysis and its applications to Epidemiology and Minimum distance estimation,

Efficient estimation of p in $B(n_i, p)$ when the n_i are constants or realisations of i.i.d. random variables.

Asymptotic tests regarding the order of finite Markov chains, Robust Multivariate Inference, Bayesian Inference and Asymptotics, Nonparametric estimation of discontinuity and Multiple regression for circular data.

3. Design of Experiments

Optimal growth and related designs for random coefficient regression models were investigated and characterised for both estimation and prediction problems. Analysis, connectedness and optimality of row-column designs and block designs, Partitioned linear models and associated reduced models were investigated with fruitful results.

4. Sample Surveys

Allocation of sample size in stratified sampling and optimal utilisation of auxiliary information in sample surveys is studied further and some techniques of allocation of sample size are proposed.

Use of multivariate auxiliary information under various situations was studied. This is useful in socio-economic and agricultural surveys. Results obtained based on inverse sampling are useful for estimating rare proportions for various ethnic/socio-economic groups and studying occurrence of rare diseases.

5. Probability and Stochastic Processes

Some topics in this direction include

Random walks in strategic finitely additive set up. Purely non-atomic random walks are discovered in this set up in contrast to the countably additive set up. Embedding of Ito calculus in infinite dimensional setting and unified framework for stochastic calculus. Convergence rates in CLT have also been studied with some interesting results.

6. Applications

(a) Geological mapping using methods for deleting change points and new model selection rules,

(b) A study of effect of jute dust on lung functions of jute workers,

(c) Application of statistical techniques in Quality Control, Astrophysics and Environmental studies, Control of production processes when the underlying characteristic is non-normal,

(d) Inference in social Networks,

(e) Epidemiological problems : (i) Prevalence of Dysplacia and (ii) Arsenicosis (jointly with Biochemistry Unit of ISI and SSKM Hospital, Calcutta)

(f) Statistical Analysis of diabetes and renal diseases, diabetes related amputations and functional disabilities in nursing home residents.

Projects

1. Robust Multivariate Inference

This is an on-going project which started in April 1993. An adaptive transformation and retransformation technique was developed that turned out to be quite useful in robust and efficient analysis of spatio-temporal data and data arising from biomedical studies. Currently an empirical investigation is being carried out into the relationship of systolic and diastolic blood pressures of people residing in certain parts of Calcutta with their ages, heights, weights etc., using this newly developed technique. Possible applications of the methodology in the analysis of spatio-temporal data (e.g. changes in the distributional pattern of Indian population over time and space) are also being investigated.

2. Exploratory Generalised Regression

This is also an on-going project which started in April 1993. Several techniques for exploratory analysis of regression data arising in industrial, socio-economic and biomedical studies have been developed. Recently scientists at the National Chemical Laboratory (Pune) have exposed the team to some statistical problems related to the modeling of the kinetics of certain catalytic chemical reactions based on experimental data. The problems are of vital importance in chemical engineering and are currently being investigated. This investigation partly involves extensive amount of computer simulations and other numerical as well as graphical work.

3. Statistical Techniques as aid to Geological Mapping

This project funded by CSIR started in 1995. The project aims at providing a statistical method aiding geological mapping with a view to replacing the existing techniques which are essentially subjective. Initially the problem of identifying a geological formation has been posed as a 2-dimentional problem of locating boundaries from a continuum of possible choices suggested by the existing contours. A finite collection of possible boundaries has been identified as an approximation to the continuum.

4. Publication of Selected papers of C.R. Rao

Volume III has come out and is being distributed by Wiley Eastern. Work on volume IV is underway and efforts are made to expedite the publication. Work on volume V has started.

5. Mathematical Olympiad

The Regional Mathematical Olympiad 1995 for West Bengal sponsored by National Board for Higher Mathematics for class 9, 10 and 11 students was organised on 3 December 1995 at Calcutta, Kharagpur, Kalyani, Burdwan, Behrampore and New Jalpaiguri in which around 300 students have taken the test. Based on this test a group of 30 students were given the Indian National Mathematical Olympiad test in February 1996 and finally six students were selected from them to be trained at Bombay International Mathematical Olympiad, to be held in India in July 96.

Delhi Unit

1. Probability and Mathematics

Research work continued in the areas of Markov processes, Martingale problems, Stochastic control, Filtering theory, Infinite dimensional stochastic differential equations, The theory of nonnegative matrices, particularly Perron Frobenius theory,and generalized inverses, Matrix and Operator Theory, Inequalities, Stochastic games and Linear Complementarity Problem.

2. Statistics

The areas where research continued include Optimality of designs under resource constraints, Construction of asymmetric orthogonal arrays, Incomplete block designs for diallel crosses, Optimality of block designs and robustness of designs against missing data, Estimation of a common mean. Global Cramer-Rao type inequalities, Reliability Theory, Survival Analysis, Inference and Stochastic Orders.

Bangalore Unit

1. 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 was done on various aspects of geometry of Banach spaces and interesting results about representable operators in the space of bounded operators from $L^1(\mu)$ to a Banach space with some conditions where μ is a finite measure on $(\mathcal{X}, \sigma)$.

Hardy's theorem which may be considered as another expression of uncertainty principle in harmonic analysis has been generalised to the uncertainty principle in harmonic analysis on Heisenberg groups, the Euclidean motion groups, a class of noncompact semisimple Lie groups and for certain given function expansions. So these investigations can be viewed as a study of the "uncertainty Principle" on certain Lie groups and manifolds.

Wiener-Tauberian theorems have been revisited and some connections with "Pompeiu Problem" have been established. The model theory for homogeneous contractions was investigated. In studies on Hilbert modules of analytic functions some complete characterizations of the quotient module was obtained.

The notion of primitive pseudo manifolds was introduced and it was shown that these are, in a cannonical way, the building blocks of all pseudo manifolds without boundary. Using this result, all δ-dimensional pseudo manifolds on $\leq (d+4)$ vertices are classified and enumerated.

2. Probability Theory

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

3. 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.

Some interesting results in the expansion in the classical multinomial theorem have been established.

Applied Statistics, Surveys and Computing Division

The ASSC division consists of Biometry Research Unit (BRU) and Computer Science Unit (CSU). Faculty members of the Division are engaged in Project, Research, Teaching and Training programmes, Summary of activities are given below unitwise.

Biometry Research Unit

The work on Malnutrition Related Diabetes Mellitus (MRDM) and Fibrocalculous Pancreatic Diabetes (FCPD) continued during the year. The research tried to identify the aetiological factors of this disease. The HLA studies indicated that DR_3 and DR_4 associations are more prominent in these patients. The fasting and post glucose C-peptide and insulin levels of these patients show their dependence on the patients' nutritional status. From the immunological experiments it has been found that their IgG levels are much on the higher side.

Application of Biometric techniques related to growth of Indian major carps, theoretical description of carp growth by longitudinal analysis of live data generated in the laboratory, specially to overcome the "lag phase" as exhibited by negative velocity and acceleration of the growth parameters in an earlier study and the effect of pesticidal pollutants on Indian major carps for the retardation of growth, are the studies undertaken

in Fisheries Sciences. Application of selected diets seems to compensate for the negative velocity and acceleration of growth.

1. Fishery Science

The longitudinal growth studies of the major carps, *Catla catla & Cirrhinus mrigala* by considering the major biochemical parameters, protein, lipid, glycogen along with the digestive enzymes in controlled laboratory conditions with selected diets have been pursued during the year, 1995-96. Autoregression and Finite difference methods are being applied to the data generated in the laboratory for prediction of the secretion of digestive track enzymes responsible for ontogenic growth of the species by supplemental feeding. A LDA package program was used for the study.

The highlights of the results are :

(a) determination of the average velocity and acceleration of growth rate of the carps, *C. catla* and *C. mrigala* in terms of the physiological and biochemical parameters of growth, viz., length, weight, protein, lipid, glycogen and the digestive enzymes.

(b) improvement of the growth rates of the carps by twenty five percent by the application of supplemental diets,

(c) location of the 'problem area' of growth where negative velocity and acceleration were observed.

2. Biomathematics

Collaborative work on the application of conventionl mathematical techniques to describe the phenomenon of blood flow under stasis is in progress jointly with Physics & Applied Mathematics Unit.

Progress :

Some characteristics of pseudo-Newtonial flow of blood through an artery with mild stenosis have been investigated within the framework of a simplified model. Assuming the blood as primarily a suspension of red cells in plasma and its viscosity dependent on hematocrit, the velocity component in the axial direction, wall shear stress and the pressure gradient have been determined analytically. Wall shear stress and the pressure gradient differed in the stenossed artery significantly from the normal case.

The utility of this study lies in its possible application on medical diagnosis of stenosis in artery.

3. Biomedical Science

(a) Investigation into Fibrocalculous Pancreatic Diabetes (FCPD)

Progress and highlights

The progress of this work upto this date is quite satisfactory. The data so far have revealed that the disease is not geneticaly inherited as only 11.2% of the relatives of our patients are found to be diabetic. Since the patients possess high IgG and IgA level, it is presumed that some immunological disturbances might have developed in them. Our HLA studies show that they may be a sub-class of IDDM. C-peptide and Insulin assay clearly indicate that nutritional status play an important role in them. It is also interesting that 60% of these patients show diabetic retinopathy.

(b) Role of Interleukin 8 (IL-8) on the Regulation of Some Infectious Diseases

Progress and highlights

Interleukin-8 plays an active role in the induction of inflammatory response in some diseases. Work on the regulation of IL-8R expression, through which IL-8 activity is manifested are in progress. Upto now the study has been able to demonstrate that serum activated LPS (Lipo Polysaccharide) at a concentration 10 ng/ml

induces expression of functionally active IL-8R by 120% within 30 minutes through denovo protein synthesis. This significant observation shows that stimulation of PMN's with LPS induces IL-8R expression which enhances the IL-8 mediated biological responses and provides evidence for post stimulatory restoration of receptor level on neutrophil surface by proteolytic cleavage of the aminoterminal end of the receptor.

Projects

1. Observations of Malnutrition Related Rickets in Childhood Diabetes

This study reflects that diabetic ostesopenia (reduced bone density) affects many IDDM patients and increases their susceptibility to fractures. Bone loss is rapid in the first 2 years after diagnosis, declining to a steady value by 5 years. Poorly controlled IDDM patients, probably, suffer proportionately geater bone loss than those enjoying good metabolic control.

The observations show that diabetic osteopenia is a low turnover state, with reduced bone formation and continuing resorption. It is interesting to note that diabetes has little effect on the mineral content of bone or on serum calcium levels, although keto acedosis and hyperglycaemia may cause magnesium and phosphate depletion.

2. Carp Growth by Nutrients and Pollutants and the Histopathological and Physiological Changes in the Gastro-intestinal Tract of Air-breathing Fish Exposed to Pesticides.

Growth performance in terms of pattern distribution of digestive enzymes in different regions of alimentary canal of *Catla catla* and *Cirrhinus mrigala* was tested by experimental diets prepared in the laboratory and the results are encouraging. The formulated diet based on gross energy level of 414 kcl/100 gms and crude protein level of 33.5% resulted in a significant increase in weight gain of *Cirrhinus mrigala* compared to *Catla catla*, that is, the growth of *Cirrhinus mrigala* under this experimental dietary treatment is much more effective that of *Catla catla*.

Computer Science Unit

Scientists of the Computer Science Unit are involved in all activities related to teaching and training in the institute. Some members collaborate with members of other units of ISI on joint projects. CSU is fully responsible for conducting the course "Intensive course on programming languages". This unit also conducts several teaching/training programmes like winter/summer schools and workshops. Currently, there are collaborative ongoing projects with Stat. Math. and Social Science Divisions.

1. Biostatistics

Quantitative methods have been developed under a two stage model for hepato carcinogenesis data on numbers and sizes of premalignant clones. The methods which appear to be valid for moderately or large sized clones are currently being modified to make them applicable for very small clones. Distributional results have been obtained and methods of analysis developed for correlated, repeated observations on a single subject in dealing with skin papillonca.

The use of Markov chain method is being explored to analyse cancer data specially in dealing with heterogeneity in cell dynamics between animals. A test of homogeneity across different dose groups based on Poisson count data at different time points has been developed and tried with data on number of premalignant clones. Work on extending this approach to incorporate size information on clones is in progress.

2. Computer Science

Cellular automata (CA) are discrete dynamical systems in which cell values evolve synchronously in discrete time steps according to the combinational logic embedded. On 2-dimensional CA 9-neighbourhood linear rules are studied with special emphasis on their algebraic properties and state transition diagrams. Some interesting mathematical results are obtained in this connection and others are under investigation.

CA have been used to design cryptographic systems at the hardware level for several data communications and the research is in progress for application of CA to the data compression problem.

3. Design of Experiments, Combinatorial Methods and Their Applications

Optimal/efficient repeated measurement designs have been developed with fewer and varying number of experimental units and time periods, compared to the designs currently known in literature. The suggested designs, which allow for the estimation of all relevant effects are more flexible and economical, and so should be useful to the users of such designs in various disciplines, such as clinical research, pharmaceutical studies etc. Also under investigation is the development of new repeated measurement designs where, instead of treating all treatment comparisons at par, as is usual in literature, one estimates some chosen comparisons with higher efficiencies than others, thereby getting designs which are theoretically interesting, much smaller in size and practically useful.

Construction problems of strongly balanced uniform repeated measurement designs, both in the linear and in the circular cases, have been satisfactorily dealt with. Generalized concepts of nearly balanced uniform repeated measurement designs and second order RMD's are introduced. Construction problem of such designs has been solved for some class of parameters. The problem in its full generality is under investigation.

Routing algorithms of street sweeper vehicles have been considered under the multifarious constraints that are involved in municipal street sweeping operations. Interesting graph theoretic and combinatorial problems are involved in the process of developing efficient solutions. The general problem has been shown to be NP-complete. Various extensions of the algorithms are under consideration and an $\in$-approximate algorithm has been developed for mixed graphs.

Combinatorial aspects of designs are studied particularly with respect to characterising the well known class of lambda designs. Some characterisations have been obtained under structural and parametric conditions.

4. Generalized Regression

Likelihood based non-parametric regression method has been developed in multiparameter and multiresponse situations with some analysis of simulated and real life data. Extension of the methods to longitudinal data is under investigation.

Estimating equation based method has been developed for regression data, assuming only the mean structure and nonparametrically estimating the variance structure using kernel smoothers. The extension of the approach to likelihood based methods is under study.

5. Linear Models

An indepth study in linear models has been made of the effects of observations and regressions on collinearity. Sharp bounds on these effects have been obtained and made use of in designing a new observation for reducing collinearity.

A unified approach to inference in general linear models has been developed using linear zero functions. An attractive feature of the work is that the case of singular linear models is dealt with without much additional work, leading to simple proofs of some existing and new results. An extension of the approach to estimating the components of variance is under investigation at present.

6. Multivariate Analysis

Significant work was also carried out in semi parametric statistical classification problems and other areas of multivariate statistical inference, neural network, directional data analysis, change point and slippage problems in circular data and optimal test procedures for multiparameter mixture distributions.

7. Reliability, Life Testing and Survival Analysis

A nonparametric goodness of fit test is proposed for the proportional hazard model by broadening the normally used alternative hypothesis to increasing cumulative hazard ratio distributions, which appear to be more realistic in the context. The properties of the test are studied. Another work on survival analysis is the compilation of the various graphical methods for data with modification suggested to enhance the usefulness of the methods and the introduction of a few new methods.

Currently investigation is being carried out on analysis of competing risk data with cause of death arbitrarily missing. Estimation using EM algorithms has been worked out. Counting process approach is under study in the context.

Estimation of component life time distributions from data on system life times of a coherent structure has been worked out. The investigation of estimation methods with intermediate observations on the system and its components is under consideration at present.

8. Sample Survey

Certain innovations are made in three-stage sampling with unequal probabilities in the context of an actual survey related to rural indebtedness undertaken by ISI.

Brewer's asymptotic technique has been and is being applied in direct and randomised response surveys in one and two phases covering quantitative data admitting regression estimators and also in developing appropriate small domain statistics. Bayes methods in various forms are also being employed in deriving small domain estimators. Measurement error models are studied in estimating finite population totals and variances and small area parameters. Some significant results are reported. The work is still in progress.

A survey project is undertaken to examine 'intergeneration occupational mobility' in Calcutta.

Projects

1. Winter School on Analysis of Directional Data (Project Leader : A Sengupta)

The second Winter School on Analysis of Directional Data was held during December 11-16, 1995. Participants and faculty from various areas of applied sciences and defence organisations attended the School.

2. Software Package for Directional Data (Project team : A Sengupta, C.H. Sastry)

This is an ongoing project on software package development for directional data. So far programmes have been developed for diagrammatic/pictorial representation of descriptive statistical tools, robust parameter estimates, and statistical testing procedures, goodness of fit tests, model selection etc. in a semi parametric framework for circular data.

3. LAN Environment (Project team : C.H. Sastry, S.C. Kundu, A.K. Das)

This project was meant to install a LAN environment in CSU P.C. room. A NOVELL software has already been installed with appropriate hardware. The system is operational.

4. Occupational Mobility (Project Leader : P. Mukhopadhyay)

"A Study of Intergenerational Occupational Mobility among the Residents of Calcutta" is a survey project to study occupational mobility of residents of Calcutta. A random sample of eight NSS-blocks has been selected from the CMC area. The schedule has been designed, code lists and instructions have ben prepared. The field work is over. Around one thousand households have been surveyed and the data collected on the attainment of educational level, occupation and migration (among other characteristics) on the members of two generations corresponding to the head of the household. Tabulation work is in progress.

5. Study of Rural Indebtedness in West Bengal (Project Team : Bimal Roy, Sushama Bendre, Ajay Kumar Adhikari, Arijit Chaudhuri, Anup Dewanji, Nityananda Sarkar, Arun K. Adhikary, Roma Choudhury & N. Bhattacharya)

All India Debt and Investment Surveys (AIDIS) are conducted decennially since 1951-52. Results of earlier years, specially in 1981-82 have revealed that estimates based on household enquiries are quite different from the general belief and expectation and have given rise to doubts on the reliability of survey estimates. In particular, estimates of debt owed to institutional sources based on the AIDIS differ significantly from figures available from institutional lending agencies.

This project aims to investigate possible causes for this difference and find the effect of each such cause on the estimates. The study was carried out in 8 blocks of two districts in West Bengal. Two approaches were taken for the study : (i) usual household approach & (ii) financial institution approach. In the latter approach, a sample is drawn from the list of loanees supplied by the financial institutions. Estimates of different parameters of indebtedness from both the approaches have been obtained and compared. The compilation, data collection and tabulation, and analysis have been completed. The final report is now published.

6. Application of Two Dimensional Cellular Automata (Project Team : P. Palchaudhuri, Bimal Roy, Rana Barua)

This project relates to the study of cellular automata of various dimensions, particularly in 2-dimensions, the investigation of their theoretical properties and practical applications. For a class of 2D cellular automata, several algebraic properties have been found out. Application to cryptology have already been reported. Work is in progress to apply 2D automata in areas like data compression, production of fractals etc.

Externally Funded Projects

1. Impact of Small Industries on Rural Consumption

Arijit Chaudhuri is involved in the externally funded project on "Impact of Small Scale Industries on rural consumption", funded by West Bengal Govt. and conducted by Sociological Research Unit of ISI.

2. Development of Statistical Techniques as an Aid to Geological Mapping (Project team : J.K. Ghosh (Stat-Math Unit) and Tapas Samanta (CSU)).

This is a CSIR funded project.

The project aims at providing a statistical method aiding geological mapping with a view to replacing the existing techniques which are essentially subjective. Initially the problem of identifying a geological formation has been posed as a 2-dimensional problem of locating boundaries from a continuum of possible choices suggested by the existing contours. A finite collection of possible boundaries have been identified as an approximation to the continuum. Models for the data have been set up assuming a given configuration of boundaries. The model (configuration of boundaries) best fitting the data has been identified using the method of maximum likelihood. Methods are being tried to use/develop Bayesian methodology for selecting the best model.

3. Tracer Study of ITI Certificate Holders (Project team : A.C. Mukhopadhyay, Bimal Roy and Palash Sarkar)

"Tracer Study of ITI's trainees in Eastern India" is a project funded by World Bank through CSTARI. A tracer study of ITI certificate holders in the job market is carried out by the Central Staff Training & Research Institute. CSU's involvement was in (i) designing the study (ii) overall supervision of the field work (iii) data compilation, preparation of tables and analysis. The study was carried out in two states : Assam & Orissa for the students who passed out in 1991, 1992 and 1993. The survey work is complete and also complete are data entry and data processing work. ORACLE 7.5 is being used for data entry and table preparation. The final report is under preparation.

Physical and Earth Sciences Division

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

Chemistry Unit

1. Distribution and characteristics of allophanic materials in soils of West Bengal

Previous research findings of the unit hinted at the possible existence of allophanic substances in some soils of West Benal. As these materials are important in modifying some soil properties and its almost decisive role in aggregate formation we took up this project to make our soil studied more comprehensive.

Weakly developed acid soils formed out of basic rocks under forest cover were found to contain appreciable amount of these materials in the clay fraction. Aabsorptive and other interaction of the isolated allophanic material and nutrient cationis were studied. Gelling property of these materials and consequent aggregate size and shape was intensively studied. Allophanes from soils exhibited varying degree of cation enchange capacity and exist in combination with considerable quantity of organic matter.

Two papers have so far been communicated on these aspects. We have also offered an equation connecting the allophane-content and size distribution in soil aggregates.

2. Heavy metals in soil

This project deals with the heavy metal behavior in presence of various soil components. This fledging project was taken with an eye on plant nutrition as well as ground water pollution. The latter object is more in with the present spate of ground water pollution too. One senior research fellow has been carrying out the main bulk of work.

Computer Vision and Pattern Recognition Unit

1. Mathematical Morphology, Dot Pattern and Cluster Analysis

(a) An efficient approach based on mathematical morphology has been developed to detect circular objects in a scene. Also, mathematical morphology has been extended to detect shape of dot patterns.

(b) The task of shape identification of dot patterns has been considered. A new shape definition called S-shape has been proposed. It has been refined to r-shape which can be computed in linear time while other existing techniques take O (NlogN) time.

(c) An improved multi-seed data clustering algorithm has been proposed. It has been demonstrated that the algorithm works quite efficiently. Detection of clusters within a cluster is being worked out.

(d) Another problem considered is the clustering of noisy and imprecise data. Extensions of existing algorithms are being studied.

2. Computational Linguistics, Natural Language Processing and Speech Analysis

(a) From a large corpus, statistical analysis of Bangla text is continued. Statistical analysis of phonemic representation of the data has also been done.

(b) Morphological processing of Bangla words is being continued and the methods developed earlier are being improved.

(c) A generalised lexical functional grammar has been proposed for syntactic analysis of Bangla text. At present tree adjoining grammer is also being generalised for the syntactic processing.

(d) Some work on Bangla verb analysis has been started and rules are being formulated for parsing of compound verbs.

(e) A spell checker prototype has been designed for non-word error detection in Bangla text. A correction strategy has been formulated. It is being extended to take care of some real word error detection.

(f) Computer implementation of grapheme to phoneme conversion rule has been worked out. Work is in progress to produce speech mode output of OCR and spell checker already developed. The work will be useful for the visually handicapped.

3. Optical character recognition and document processing

(a) The prototype Bangla OCR system already developed is being improved to recognise multi-font Bangla documents.

(b) A Devanagri (Hindi) OCR system is being developed. Work is continuing to integrate Bangla and Devanagri OCRs.

(c) Preliminary study has started on South Indian Language OCR like Telugu and Tamil.

(d) Work is in progress for automatic identification of tables and mathematical expressions in a complex document. Automatic merging, appending and restructuring of tables are also being worked out. A table algebra has been proposed for electronic table generation and manipulation.

4. 3D Digital Geometry and Biomedical Image Processing

(a) The problem of confocal microscopic (CM) image processing has been considered. Multiple layers of CM images are being combined to make a 3D cellular representation.

(b) 3-D binay image thinning and skeletonization algorithms have been proposed.

(c) Work has started on Medical Image Database Management Systems.

5. Neural Networks

(a) An adaptive method has been developed to update, in an autonomous way, the learning rate of the backpropagation algorithm for a multilayer perceptron. This method assumes that each individual weight has its own learning rate parameter and updates it on the basis of the steepest descent principle. In this context a new concept, namely, the effective value function of the learning rate, has been defined. The new adaptive algorithm has been found to be useful in some real life problems and has produced much better performance in terms of convergence speed than the original backpropagation algorithm. The applications considered are (i) high dimensional astronomical data analysis problem and (ii) texture segmentation problem which does not consider a feature set.

(b) A new neural network model of self-organising has been proposed. The model is dynamic in the sense that both the topology and the size of the network can grow or reduce during the learning process depending on the input data. The network has been used for efficient shape representation. A unified approach to skeletonization of patterns (binary or gray level images or dot patterns) has been proposed on the basis of the new model. The robustness of the proposed shape representation approach in comparison to the existing approaches for the same purpose, has been established.

Externally Funded Project

Automatic feature extraction from satellite images (funded by Department of Space)

Electronics Unit

During the period 1995-96, the faculty members of the Unit were engaged in research in the field of Computer Science. The research areas include Parallel Algorithms and Parallel Architectures, Network Topology, Interconnection Networks, VLSI Layout Design, Computational Geometry, Logic Synthesis and Design for Testability, and Discrete Event Simulation.

1. Parallel Algorithms and Parallel Architectures

The objective of research in this area includes the following :

(a) 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.

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

(c) Testing and design for testability of systolic arrays

A new parallel algorithm for fast multiplication in redundant quarternary number systems has been developed. Algorithms for Lagrange's interpolation with a) O (log n) time and O (n^2) processors and b) $O(n/\log n)$ time and $O(n \log n)$ processors have also been developed. An $O(n^{1/4})$ parallel algorithm for sorting on the Multi-Mesh architecture has been developed. Parallel algorithms for solving polynomial equations using Graeffe's root squaring technique have been developed. An efficient parallel algorithm for forecasting has also been proposed.

2. Network Topology

The objective of this study is to substitute topologies or 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 topology, called Multi-Mesh (MM), has been introduced with many interesting topological properties and it has been shown that many real life algorithms involving numerical processing, image processing, signal processing can be very efficiently mapped on this topology with time complexities of much lesser order than those when they are implemented on the 2-D mesh/torus with the same number of links per processor.

Another new topology based on Fractal Graphs has been proposed and its topological properties have been studied. It appears to be useful for efficient implementation of recursive algorithms.

3. Interconnection Networks

A generalized shuffle-exchange interconnection network has been proposed for applications where the number of inputs/outputs is not a power of 2. The new network utilizes minimal hardware, and therefore is cost-effective as well as simple. Routing algorithms also have been developed for these networks. It has been found that the reduction of cost does not adversely affect the routing complexity. Moreover, there exist some redundant paths for some source-destination pairs, which makes the network fault-tolerant in the presence of some faults. The properties, regarding fault-tolerance and rearrangeability of this proposed network are being investigated.

The performance of the self-routing algorithms proposed by us is under study, for various sizes of Benes network. So far the results show that for lower values of N, almost 80% of all possible permutations are self-routable in Benes network.

4. VLSI Layout Design

The physical design phase of VLSI (Very Large Scale Integration) circuits involves many problems on partitioning, placement, floorplanning, wire routing and area compaction. Furthermore, variations of layout style, technology, and packaging, e.g., FPGA's (Field Programmable Gate Arrays), and MCM's (Multi Chip Modules), lead to numerous design and optimization problems, the formulation of which needs graph theory and combinatorial optimization. In this project, our objective is to identify various VLSI design problems which can be efficiently solved using the paradigms of computational geometry. We believe that these new techniques, by virtue of their inherent power and novelty of spatial data structures and search methods, will outperform or augment the conventional EDA (Electronic Design Automation) tools. In addition, these techniques will have manifold applications to defence, robotics, database, and pattern recognition.

5. Computational Geometry

We have 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 have been proposed. The algorithms also include recognition of max-width/area empty staircase channels, 3D cuboids etc. We also introduced the shooter location problem and proposed efficient algorithms for solving it.

6. Logic synthesis and Design for Testability

We have developed a new technique for synthesis of large synchronous sequential machines. The proposed design has less hardware overhead, shorter test application time, and a very high fault coverage. The design can easily be mapped to a FPGA based architecture.

Synthesis of very large sequential machine now forms an integral part of high performance ASIC VLSI ships. Typically, such a circuit might consist of 30,000 logic gates or more. The circuit is described in VHDL environment; then steps of partitioning, finite-state machine synthesis, and final logic design need to be performed.

To check the correctness of the design, it is required to have an extensive simulation study. This involves : (i) logic simulation, (ii) fault simulation, (iii) timing simulation and (iv) layout simulation. If any design error is identified during simulation, it is corrected and the process is iterated.

7. Discrete Event Simulation

Discrete event simulation is indispensable in evaluating the performance of a parallel processing system. In our array processor-based system, performance of various computer networks and parallel algorithms are being studied. Study of such designs will also require discrete event simulation in a large scale. Typical examples are job queuing, deadlock, broadcast, message routing protocol etc.

Various studies on the development of efficient methodologies for discrete event simulations have been carried out. A Parallel Virtual Machine (PVM) environment is also created and developed on a PC.

Large scale simulation studies have been made to assess the performance of a (64 x 64) baseline switching network with output buffering. It has been observed that the output buffering scheme provides more throughout and manages huge traffic quite efficiently. The traffic rate was varied from 20% to 100% whereas, the number of buffers in a queue within a switch was varied from 1 to 2.

1. Theoretical and Experimental Investigations in Computer Vision, Pattern Recognition, Biomedical Imaging and Image Analysis

(a) Development and implementation of mathematical morphological tools and techniques for object recognition and inspection : To extract partially occluded circular objects from cluttered scene an algorithm is developed. Morphological algorithms for generating various types of convex hull as well as testing objects for various types of convexity are suggested.

(b) Development and implementation of algorithms of binocular/trinocular stereo vision : New algorithms have been developed for extracting edge and line features from gray level images as well as for extracting single pixel thick lines and arcs in 2D binary images. The results can be used for matching features in stereo image pair to establish correspondences.

(c) Integration of multisource data having different spectral and spatial resolution : These could be used as an aid for registering a set of multi-modal images. Classification based on higher spectral resolution data are continued.

(d) Synthesis of images of talking face synchronized with speech sound : Storing only the images with significant leap position and generating images of the face for in-between leap movements suggested. On analysing input speech data an index is to be generated with which image from the secondary storage is retrieved and loaded on the video memory.

(e) 3D digital topology and image processing : New characterizations and computational methods for 3D simple points and other local topological parameters have been developed. Using the simple point characterization a new shape preserving parallel 3-D thinning algorithm has been developed. Robustness of the algorithm under noise and rotation is analysed. Using local topological parameters a new approach to segmenting 3D digital objects into meaningful components has been developed. A new parallel method of computing the Euler characteristic of 3D digital objects has been developed. Rigorous theoretical analysis has been made on the subject and important properties are found.

(f) Studies on multimodality biomedical imaging : A point landmark based registration techniques for identical cross-sections of CT and MR images has been evolved. Currently a moment based registration method is being developed for images with inherent symmetry. A fuzzy c-means to measure the goodness of match and the 2D shape metric have been developed for structures of anatomical interest.

2. Remote Sensing and Data Analysis in Atmospheric Science and Wave Propagation

(a) Studies on the propagation characteristics of mm wave signal : Statistical analysis of fade data continued for the classification of different mode of the microwave/VHF propagation. Nature of fluctuations in refractivity at various ABL zones and their distributions studied. Planning of attenuation studies of the propagating HF wave around the cities with high environmental noise and presence of smog/fog has been made for execution of scientific experimentation. Analysis of fade information (18 GHZ mm wave link operated by Eastern Railways at Khana - Galsi route) is being done.

(b) Studies on aerosol by LASER techniques and pollution dispersion : Restricted laboratory experimentation has been completed successfully to get the back-scattered information in the receiving section to determine the presence of fog layers and other suspended aerosol within the low elevation layers. Investigations on the fractal dimension of pollutant dispersion and in different velocity field has been investigated. A model for nonsteady dispersion of pollutant in homogeneous turbulent field has been investigated, and extension of the model is being planned.

(c) Development of a knowledge-based system for interpretation of atmospheric patterns : Suitable computer algorithms using image processing and computer vision techniques have been implemented for the enhancement of image quality and subsequently recognition of sodar imagery patterns. Noise separation

algorithms are developed for extraction of atmospheric images. ABL structure boundaries extracted with the above techniques are modelled mathematically. In another work multithresholding techniques applied to identify and classify the boundary and patterns of associated clouds and also their motion estimation.

(d) Modelling of the ABL parameters : From the recorded sodar and tower data at Calcutta, Varanasi and Kharagpur studies have been continued on the randomness turbulence, associated in the ABL. For this purpose the temperature/velocity field of the lower atmosphere have been considered. More detailed analysis of the fractal aspects of the PBL dynamics (randomness in velocity as well as thermal field, inhomogeneous vertical convection etc.) have been studied and has been reported in journal.

3. Statistical Studies on Acoustic Phonetic Characteristics of Indian Speech and Musical Sounds with a view to Automated Speech Recognition

(a) Acoustic phonetic study : Acoustic phonetic studies on Assamese language are continued with spectrograms of 360 words in Assamese language for 2 male and 1 female speakers. As usual the distributions of formants are found to be responsible for vowel discrimination. The acoustic phonetic study of plosive consonants will be taken in next phase.

(b) Perception experiment : To find features for different manner of production in speech recognition, perception experiment for distinction of voiced/unvoiced unaspirated plosives is continuing. Conclusive evidences have been obtained contradicting age-old convention that perception of phonetic category is a frequency-domain affair. A tanpura with four strings well tuned to pa, sa, sa, sa is known to produce the sensation of many other notes to properly tune ears. Recently it has been observed that occurrences of an isolated strong harmonic in 2.5 - 3 kHz range, whenever the sensation of ni' occurs. This apparently creates a tone in the background due to auditory segregation. An extensive study of the phenomena is being planned using manipulation of actual tanpura sound to produce other notes.

(c) Speaker independent world recognition : Work on word recognition is going on using fuzzy logic and back propagation type neural network. In another experiment, approximate reasoning approach to PR of vowel speech sounds of major Indian languages has been attempted successfully. Application of this method for Telugu, Bengali and Assamese vowel recognition provides promising results. This method will also be applied to recognise plosive consonants.

(d) Indian music : Recently a large volume of actual performance in raga Iman by well-known mestros in music have been analysed. The findings are based on principal of consonance and human physiological parameter that led to comprehensive modification of previous model. An empirical theory for production of sound in tanpura has been proposed. The sounds show striking similarity in spectral, temporal and perceptual domain with those of original sounds.

Externally Funded Projects

1. Knowledge based computing (CSIR funded)

Some new methodologies developed for 3-D vision systems including topology preserving segmentation of discrete surfaces, characterisation of 3-D sample points based on Euler characteristics, and parallelisation of 3-D shape analysis. A theoretical study on a class of evolutionary (genetic) algorithms and their applications to optimisation problems is being carried out. An optimal stopping rule based on Wald's SPRT test is in the process of devloping to conclude that the stopping rule is attained.

2. Studies on the PBL dynamics using sodar and tower data (DST funded)

To investigate the changes in the intensity of turbulence vis-a-vis mixing under a convective system, the turbulent velocity field of the PBL and also the random temperature field of the PBL from the sodar data has been analysed with the help of fractal dimension to characterise plumes and interplume regions. A case study using the tower data on continually varying scales of scalar concentration as against the change of its gradient has been conducted and formulated.

3. Development of computer algorithm for recognition & interpretation of sodar patterns (DST funded)

Investigation is mainly concentrated into two major aspects : (i) Improvement of quality of acoustic signal (atmospheric) images echoed from different atmospheric layers. A set of image enhancement algorithms are used to increase the contrast of the signals. Grey value histograms of the respective images are used as an additional tool for comparing the results. (ii) Segmentation of sodar image (digitised sodar record) for interpretation of ABL structure is done by adopting a fuzzy c-means classification algorithm. The classified images are compared to the previous segmentation techniques, and the results achieved prove the elegance and definite merits of the proposed technique.

4. A knowledge based framework for diagnosis & therapy planning using multimodality medical imaging (DST funded)

Attempts are being made to develop a knowledge based framework for diagnosis and therapy planning using multimodal medical imaging in collaboration with AIIMS and other organisations. The aim of this project is to integrate the data corresponding to the salient features of each imaging modality as CT, MRI, MRA & SPECT in a fused display. To this end, some work has been done on image registration of CT and MRI images and is found to be suitable for matching shapes corresponding to structures of interest. A 2D shape metric has been defined to assess the goodness of match between two images. This shape metric can be used to study the progress of a disease. Work in progress includes the study of the efficacy of different filters smoothing, edge enhancement, region segmentation of cross-section of CT and MRI images and also fuzzy c-means classification of tissues from MRI and CT images to obtain an integrated display.

Geological Studies Unit

During the period from April 1995 to March 1996, the scientific workers of the Geological Studies Unit carried out twentyone (21) research projects in connection with its programme of basic research centred around some Precambrian, Gondwana and SupraGondwana basins/areas of peninsular India, namely, the Pranhita-Godavari basin (A.P. and Maharashtra), the Cuddapah basin (A.P.), the Chattisgarh basin (M.P.), the Satpura basin (M.P.), the Eastern Ghats (Orissa), and the Rajasthan Proterozoics. The broad areas of activities are described under four heads - Precambrian, Gondwana, SupraGondwana and Quantitative Geology/Computer Applications. It may be mentioned that

(a) the Precambrian research involves working out the history of the crustal development of the southeastern part of the Indian peninsula integrating tectonic, stratigraphic, sedimentologic, structural, magmatic and metamorphic studies;

(b) the Gondwana research concerns working out the history of sedimentation, life, palaeoclimate, etc., in course of the entire period of the Gondwana sedimentation in some selected parts of the peninsular India;

(c) the SupraGondwana research deals with the enigmatic problem of the extent of Gondwana sedimentation, i.e., the upper limit of the India's Gondwana sequence; the problem has led to the research on the globally important extinction problem of the dinosaurs at the K-T transition; and

(d) attempts are made for analysing any meaningful data naturally arising out of the geological field and/or lab investigations for subjecting them to either statistical or computer - related treatments.

A project on Microemulsion was also undertaken and conducted by the Unit.

1. Precambrian

The study of the Delhi metasediments, east of Kharwa, Ajmer dt., Rajasthan, has mainly been carried out on (1) the geometry and the history of the fold and fault sets developed, (2) the Delhi stratigraphy in relation to the large-scale superposed folds, (3) the shear zones within the Delhi metasediments, and (4) the basement (BGC) - cover (Delhi) relationship.

The details of the structure and stratigraphy in some key sectors of the Nallamalai Fold Belt (NFB) are being analysed to understand the kinematic framework of deformation in the Proterozoic intracratonic Cuddapah basin. Mapping and analysis of structures in the Velikonda range between S.R. Puram and Porumamilla, along the eastern margin of the NFB, demonstrate the dominating influence of west verging thrusts and folds. Structures of similar scale and with westerly vergence also occur in the western part of Cumbum/Pullampet outcrops around Rajampet in the southern Nallamalais or at Giddalur in the west-central part of the belt. Thus, consistency in the overall kinematic framework of non-coaxial deformation across the NFB is indicated. In shaly rocks, cleavage is as common in the eastern part as it is in the west; thus a layer parallel homogeneous strain (LPS) affects the whole of the Nallamalai Belt. The LPS is independent of (but generally concomitant with) the thrust development and related fabrics.

Polyphase deformation in the Eastern Ghats granulite belt has been explained in terms of more than one orogeny. Structural studies suggest a change of tectonic regimes associated with the phases of deformation. Petrological investigation reveals a multistage P-T-t path and probably polycyclic metamorphism with different types of P-T-t paths.

The structural setting around Kabbaldurga, south Karnataka, has revealed an older granulite event than the migmatitic peninsular gneiss. In Orissa, the massif-type charnockites with early structures (around Jenapore) appear to represent a differentiated magmatic suite.

The deep water carbonates (including the carbonate debris-flow conglomerates, carbonate turbidites and bedded chert - manganese horizons) of the Penganga Group in the Godavari Valley have been studied. A deep carbonate shelf - slope basin sequence within a distally steepened ramp has been identified. Bathymetric fluctuations within a transgressive - regressive cycle have been analysed. The stratigraphic variations within the Penganga Group as well as the relationship between the Penganga and the Sullavai Groups can now be studied within a model of sequence stratigraphy. The fabric analysis of the bedded chert and the analysis of the depositional environment of the chert-hosted manganese oxide deposits have been completed. The manganese had formed at the slope of a basin transition zone, well below the wave base.

In the study of the stratigraphy and sedimentation of the Proterozoic Chattisgarh sequence (with special reference to the evolution of the Chattisgarh basin) in Madhya Pradesh, data collected from three locations (viz., Sarangarh, Panduka, and Arjuni) were analysed. The basal sandstones of the Chattisgarh Supergroup at Panduka and at Sarangarh are interpreted as an alluvial fan deposit, and a fan-delta-shelf sandstone, respectively. The analysis of palaeocurrent data from Panduka and Sarangarh indicates the presence of two major palaeoslope directions at the time of coarser clastic deposition, one - a southeasterly slope - towards the Eastern Ghat mobile belt and the other - a northwesterly slope away from the Eastern ghat mobile belt. Pyroclastics have been identified at various stratigraphic levels at Sarangarh.

In the Pranhita-Godavari Valley, study of the coarse-grained alluvial sediments of the Ramgiri Formation of the Sullavai Group indicates two mutually perpendicular drainage networks coexisting during the Ramgiri sedimentation. A basin-margin drainage network, at high angle to the general trend of the basin axis, deposited the coarse-grained conglomeratic sediments; the finer grained sandy deposits, in contrast, were laid down by comparatively lower gradient, deeper streams, flowing longitudinally parallel to the basin axis.

The facies and architecture of the coarse-grained alluvial deposits of the Ramgiri Formation were strongly influenced by the vegetation-free Proterozoic landscape. Some of the features and characteristics of these sediments have important bearing on the current debate on the distinction between alluvial fan and coarse-grained braidplain deposits.

The sedimentation pattern of the Ramgiri Formation, along with the available stratigraphic, structural and geophysical data, corroborates the inferred asymmetric nature of the Proterozoic Godavari Valley rift basin during the Sullavai time. Sedimentation pattern bears remarkable similarity with the coarse-grained alluvial sediments deposited along the unfaulted margin of the present day East African rift basins.

2. Gondwana

A detailed litholog has been prepared for the entire (1100 m) thickness of the Bijori Formation in the eastern part of the Satpura basin, M.P. A cyclicity of sandstone and mudstone beds, wave-generated structures

and biogenic activity was noted throughout the sequence. The palaeocurrent data indicate a northerly palaeoflow of the feeder channels and an east-west extension of a large standing body of water.

The major lithoformations of the Satpura Upper Gondwanas in the central part of the Tawa Valley, M.P., have been analysed. Earlier survey indicated that the Permo-Triassic lithoformations, viz., Motur, Bijori, Pachamari and Denwa, are a bit different in the Tawa area than that in the central part where these can be best studied and the information can then be used in the Tawa area (where lithocharacters and facies differ a lot). A field work was carried out in both the central and the western regions in order to identify several key litho-characters of the above formations. The Moturs contain a wide red mudstone which is unfossiliferous except some fossil wood. The Pachmaris reveal a wide fossil bone-bearing clay-mudstone facies and the Denwas contain pockets of vertebrate fossils unusually rich amphibians.

Earlier survey indicates that the typical Denwa facies in the central part of the Satpura basin is not at all developed in Tawa Valley where the Pachmari Formation with very rich red clays is at places overlain by the Bagra Formation. Moreover, some parts of the Pachmari formation may well be parts of Denwa Formation in the Tawa Valley. Besides, the Motur and the Bijori Formations lose some of their distinctive characters that they possess in the eastern part. A few fragmentary amphibian bones have been obtained (for the first time) from the Pachmari red clay (near Kesla) in the Tawa Valley.

A new titanosaurid dinosaur has been described from the Late Cretaceous Infra-Trappean rocks of Dongargaon, Central India. It is represented by a nearly complete, associated and articulated skeleton that enabled it to be diagnosed as the genus Titanosaurus ; there is yet another Indian titanosaurid genera which is being reevaluated.

The Lower Gondwana rock sequence of the Satpura basin around Parasia in M.P. has been mapped, covering an area of about 300 sq. km. A lateral variation in the Motur Formation, from a clay dominant facies in the east to a sand dominant facies in the west has been documented by several lithologs. The petrographic and modal analyses of the rock samples have been completed.

The osteological study and the line drawings of an endothiodont from the Pranhita-Godavari Valley have been done. On the basis of several deformed and incomplete skull material, a complete skull has been restored to be identified as Endothiodont. A detailed study of the occipital part is being done to get a complete knowledge about the hearing faculty of the animal.

Some of the individual bioclements of the Late Triassic fauna of the Pranhita-Godavari Valley Gondwana sequence have been studied in detail. The metoposaurid amphibians, an important and abundant bioclement of the Late Triassic of P-G Valley, are being reviewed. These metoposaurids are more varied in shape than their coutcrparts in other parts of the world, and appear to be taxonomically closer to some of the North American metoposaurs. However, geographically widely separated Indian metoposaurs have some distinctive characteristics. The chigutisaurid amphibians, a very rare occurrence and restricted to India, Australia and Argentina only have also been studied.

3. Supra Gondwana

The work on the Lameta Beds and K-T extinction is nearly complete. A dozen of dinosour egg-shells has been collected from Gujarat; an excavation near Balasinor, 100 km. east of Ahmedabad, had yielded new dinosaur bones of, at least, two carnosaurs, one sauropod and an ankylosaurid. The dinosaurs, as preliminary study indicates, provide an important food for thought about their habitat in India just before they mysteriously got extinct 65 million years ago. An enigmatic question of the possibility of an Indo-European land connection at that time in some form is also cropping up. The present research suggests highly deleterious environmental consequences, a result of a huge meteorite impact side-by-side with an already started large-scale volcanic emission at the same time, perhaps led to the different tempos of extinction patterns across the K/T boundary including the extinction of dinosaurs. The analysis of the Anjar section in Kutch confirms the presence of an iridium-spike within a 65 m.y. old sedimentary layer.

4. Quantitative Geology/Computer Application

When temperature and strain rate remain constant, the quartz CPO in deformed pure quartz aggregates is largely dependent on the deformation kinematics. Asymmetry of the fabric, e.g., in type-I asymmetric crossed-girdle patterns in simulated fabrics or natural quarts tectonites or experimentally deformed quartz aggregates, is generally related to the sense of vorticity for a non-coaxial deformation. Natural quartz tectonites, however, contain micaceous impurity.

The objective of the project is to quantitatively assess the influence of mica on (i) the asymmetry of the fabric pattern, and (ii) the degree of quartz CPO, i.e., the fabric intensity.

A correlation regression analysis of the data obtained earlier for a set of 50 quartz tectonite specimens was done. The asymmetry of the fabric is independent of the modal mica content which varies from 2% to 35% of the total volume in the sample. A strong negative correlation between the mica content and the fabric intensity is demonstrated.

A new project on systematic microstructural investigation of naturally deformed quartzofeldspathic (Q-F) rocks has been undertaken with the following objectives : (i) to make assessment of the strain sensitivity of the strain partitioning between phases and deformation mechanisms and (ii) to find out how the varied feldspar content affects the development of the quartz CPO in Q-F aggregates.

5. Microemulsions

Microemulsions have been the focus of extensive research worldwide due to their unique physicochemical properties and importance in a variety of applications, viz., enhanced oil recovery, pharmaceuticals, agriculture, drug delivery, production of nanoparticles (semiconductors), reaction media, etc. Attempts were made to workout the formulation, structure and properties of microemulsion systems using vegetable oils. Investigations on their solvent properties in the light of charge-transfer complexation of a donor-acceptor system were made.

Externally Funded Project

Deformation, metamorphism, anatexis and magmatism across the northern boundary of the Eastern Ghats mobile belt around Rangali, Orissa. This project funded by the Department of Science and Technology, Govt. of India has been undertaken by Dr. S. Bhattacharya as the project leader and Sm. Suchandra Moitra as a scholar. The project envisages to sort out the boundary relation between the Eastern Ghats and Singhbhum which the structural studies conducted so far indicate an oblique collisional boundary.

Machine Intelligence Unit

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. theses. Many undergraduate and postgraduate engineering students of Computer Science, Electronics and Telecommunication, Electrical Engineering and students of MCA courses from different universities and institutes undergo their vocational/semestral training under the supervision of the faculty members of MIU.

During the period under report, research work was carried out in the following areas.

1. Pattern Recognition

Genetic algorithms (GA) have been applied for pattern classification in N dimensional feature space where a fixed number of hyperplanes is used for modeling the decision boundaries of the classes. It has been proved that as the size of the training data tends to infinity, the error probability of the GA based classifier is less than or equal to that of Bayes classifier. An alternative strategy for classification is currently being developed where the number of hyperplanes required for modeling the class boundaries can adaptively evolve

from the GA itself. This attempt utilizes the concept of variable string length. In addition, effectiveness of several other strategies like simulated annealing, linear discriminant functions and learning automata in classifying patterns in IR^N is being studied. It is found that GA based searching is more effective than that by simulated annealing in this regard.

A multivalued recognition system, which minimizes uncertainty in decision making by providing output in four states, has been successfully implemented in identifying ill-defined man-made objects such as airports, seaports, road maps and beaches from IRS image data. Various supervised and unsupervised fuzzy set theoretic models are also examined in this context. Under an externally funded project, a software package is developed on this and is handed over to defence personnel for their use. A modified version of the multivalued recognition system is also used as a medical expert system for diagnosing hepatic diseases.

A minimal spanning tree based criterion for the selection of seed points has been formulated alongwith its experimental demonstration. A split and merge clustering technique and a metric for higher dimensional data sets have been developed in this regard. A modification in k-means algorithm is suggested for reducing the computation time. A minimal spanning tree based criterion for finding α for the construction of α-hull has been found. The concept of fuzzy α-hull is also proposed.

Electroencephalogram (EEG) reflects the electrical activity of the brain in the various states of sleep and wakefulness. One of the methods for quantifying (qEEG) such activity is calculating the FFT (Fast Fourier Transform) of the EEG waves. Under different conditions of stress and exercise, the qEEG is found to be suitable as input feature to MLP (multilayer perceptron) for discrimination between normal and depressed animals.

For classifying fingerprint patterns, the use of unprocessed gray level images reduces the loss of information (and hence uncertainty) in decision making. Power spectral (1-D FFT) estimate of texture along some (4 or 8) selected directional bands has been found to be useful as input features for MLP based classification. Here the global characteristics (frequency) of fingerprint patterns are utilized. Its comparison with those of fuzzy geometrical features and other directional/textural features is made for various noisy and distorted fingerprints.

Other research projects in progress include character recognition using fuzzy neural networks, development of algorithms for assessment of clustering tendency and cluster validity.

2. Image Analysis/Processing and Computer Vision

A new smoothing algorithm for digital images using isotropic and anisotropic diffusion processes has been developed. Gray level image coding using the modified Bezier-Bernstein approximation has been developed. Data compression of binary contour images using discrete circular geometry is now under investigation. Its merits over other conventional techniques are also being studied. Second generation technique in image data compression is widely used for its high compression ratio and good fidelity of the decoded images. A new contour coding scheme using the properties of discrete circle has been developed. The algorithm is seen to yield high compression ratio for a class of binary images. Various wavelet methods for image data compression are now under investigation.

An attempt is being made to recognize and classify planar polygons using a new set of local shape descriptors, namely *extended angle* and *extended ratio*. These together with a proper measure of the direction of the extended lengths make the feature set translation-rotation-scale invariant and also help in complete reconstruction of the unknown polygon.

A new multiscale morphological edge detector has been developed. The proposed detector has better noise immunity and intensity response compared to other existing morphological edge detectors.

Fuzzy control paradigm has been used for image processing. Effective edge detection algorithms have been developed integrating human psychovisual facts with fuzzy reasoning.

The application of spatial/spatial frequency (s/sf) representation (Wigner distribution) for different low and intermediate level vision problems are currently under investigation. A new framework in analyzing the formal mathematical correspondence between quantum mechanics and time-frequency representation of signal is proposed. It is also shown that the joint time frequency distributions (s/sf) have a close link with Heisenberg uncertainty relation if the observables are taken as fuzzy entities. It is postulated that these mechanisms will be of crucial importance in highly fragmented computational structure, such as neural networks as they may exhibit a strong mutual interaction between data and operator.

3. Artificial Neural Networks

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. An application of this model for 'making connectionists' learning systems robust is also demonstrated.

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are proposed. Network models for mixed category perception which is capable of accepting absolute feature values as input are also developed. The principle of X-tron has been used to build a psychologically motivated structured connectionist system, called PsyCOP, for learning and simultaneous recognition of multiple objects. 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. The effectiveness of neural networks is being studied for thinning in graylevel 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.

Dimensionality reduction using different neural networks has been done. Selection of an optimal feature set for pattern recognition problems has been realized. An algorithm for selection of an optimal/near optimal architecture for a MLP has been developed. Application of NN for time-series analysis is in progress. A MLP based approach for determining the shape of a pattern class from its sampled points is proposed.

A knowledge based connectionist system incorporating domain knowledge has been developed for classification and rule generation. The network is then refined by learning. This helps in speeding up the net other than improving performance.

4. Fuzzy Logic and Uncertainty Analysis

Various fuzzy set theoretic operators are developed recently for soft data analysis. These include fuzzy medial axis transformation (FMAT), divergence between fuzzy sets and fuzzy Hough transform (FHT). 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 utilised in image segmentation problem. FHT enables to reduce the difficulty in detecting peaks in Houghs space and to specify approximately ill-defined image structures.

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. An axiomatic approach has been used to define a measure of conflict for Dempster-Shafer

framework. Unlike other measures of uncertainty which generalizes Shannon's information measure, the proposed one is a generalization of Vazda's quadratic entropy and it considers only the conflictual aspects of total uncertainty that arises due to the randomness in the system. For possibility distribution new metrics have been defined using different measures of non specificity. Properties of iterates of fuzzy circulant matrices under max-min operations have been investigated. Characteristics of determinants of fuzzy matrices under general S-norm and T-norm have been investigated. A shape estimation procedure has been developed with the help of fuzzy alpha hulls.

5. Neuro-Fuzzy Computing

Attempts are being 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 connectioning expert system for rule generation and inferencing has been made along with applications to real like 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. A way of integrating fuzzy set theory and connectionist system for feature evaluation has also been formulated.

One important project in this area entitled "Neuro-fuzzy system : system and implementation" has been successfully completed under the leadership of S.K. Pal who was a Jawaharlal Nehru Fellow. This project was fully funded by the Jawaharlal Nehru Memorial Fund as part of the Fellowship award.

6. Brain Modeling

The field of brain modeling has the twin aims of elucidating the methods by which information processing is carried out in biological systems (in particular, the human brain) as well as to use that knowledge for the designing of more "intelligent" machines. This involves the construction of congnitive models usually based on connectionist networks carrying out parallel distributed processing.

The conventional neural network paradigm centers around the fixed point approach. However, human memory is an extremely dynamic phenomenon. Recent neurobiological evidence seems to indicate that the dynamics of brain processes is dominated by chaotic activity. In the light of this, work was carried out on an oscillatory neural network model, which, for a certain range of parametric values, exhibited chaoticity. A chaos-control method was implemented so as to make the chaotic network converge to any one of a large number of possible periodic attractors. The high storage capacity of such a memory model as well as the extremely rapid speed of convergence promises to lead to the development of a new class of "chaotic-attractor" associative memories. This model also sheds new light on some aspects of epileptic disorders.

Another aspect of biological computation is the utility of signal synchronization among neural assemblies. Such processes seem to be employed in "visual binding" in the brain. The question of what happens if competitive synchronizing interactions occur among different neural assemblies led to the study of such interaction among three coupled chaotic "Lorenz" systems. The resultant chaotic attractor was qualitatively different from and much more complex than the conventional "Lorenz" attractor. This finding indicates that a far richer dynamics is available to the brain than was previously thought. At present an analytical investigation of such interactions is in progress.

7. Genetic Algorithms and Fractals

Genetic Algorithms, which are adaptive, parallel and robust search techniques, have been found to be useful in various pattern recognition and image processing problems. In addition to these application oriented research, some theoretical works enriching the literature of GAs have also been carried out.

An application of GAs for automatic selection of optimal image enhancement operators has been shown. The selection of optimal parameter values of multilayer perceptron and cellular networks has also been made. It relieves multilayer perceptron from using back propagation technique. A new mutation method called directed mutation is developed which accelerates the rate of convergence of the genetic algorithm to a great extent. A new genetic operator named substitution is introduced which replaces the existing worst chromosomes by randomly selected better ones so as to enhance the performance of the existing GAs. Attempts are also being made to find the optimal stopping time for GAs.

A new crossover technique, called self crossover has been developed which satisfies the constraint "cardinality (number of 1's) of the coded string remains same" but retains the stochastic and evolutionary characteristics of GA. The method provides better result for problems like travelling salesman problem and feature selection in pattern recognition compared to existing techniques.

An attempt has been made to study the effect of emulating sexual discriminations in artificial genetic algorithms. The results show a marked improvement over the conventional or a sexual General Algorithm. The schema theorem is shown to hold for the modified methodology. It is also established that in most situations the lower bound on the number of schemata sampled by the modified method is better than its conventional counterpart.

A GA based model to evolve Hopfield type optimum network architectures for object extraction has been established. The performance of Genetic Algorithms vis-a-vis Simulated Annealing for optimization is currently under investigation. A new fitness evaluation criterion for Genetic Algorithms has been introduced where the fitness value of an individual is determined by considering its own fitness as well as those of its ancestors. Efforts are also being made to develop some strategies to select mating pairs for the crossover operation.

A method has been developed for compression of images using iterated function system (IFS) with the help of GAs. GAs have helped in reducing the search space about 90% for finding near optimal transformations for coding. Further, a mathematical analysis of the proposed compression technique has also been carried out. The technique has been successfully tested on several images. Attempts are being made to develop a hybrid coding technique using IFS for better compression ratios.

The above method for compression has been suitably modified in the case of EEG signals. The performance of the modified method is good from the point of view of compression as well as clinical diagnosis.

8. Rough Sets and Logic

The theory of Rough Sets is a mathematical tool which deals with problems involving vagueness and uncertainty. As Fuzzy Set theory also deals with such problems, there naturally arises a scope of an interplay between the two. We have attempted an integration between these theories, by providing a measure of roughness of a fuzzy set. Properties of this measure have indicated possible applications for handling uncertainties in the field of pattern recognition and image analysis, and we have started investigations in this direction.

On the other hand, as part of our work in the area of logical analysis of rough sets, we have introduced a few algebraic structures and the corresponding formal propositional systems. It is found that these can be imparted a rough set semantics and moreover, respective soundness and completeness of the systems can be established. We have started a study of the relationship of these new entities with other known structures and logical frameworks.

9. Fuzzy Control

Adaptive fuzzy logic controllers have been developed using reinforcement type learning algorithms. A new concept of rule-dependent/system dependent inferencing has been introduced and its effectiveness for realizing a robust fuzzy controller has been demonstrated.

An extension of the conventional fuzzy control model has been proposed. The extended model can account for incorrect and inconsistent rules obtained from human experts or otherwise. The flexibility and robustness of the proposed extended model have been demonstrated on the inverted pendulum problem. The extended model may be used to solve the important but difficult problem of rule-selection for a fuzzy logic controller.

Work is in progress on the development of some general purpose neuro-fuzzy tools for fuzzy logic applications.

Physics and Applied Mathematics Unit

Apart from research activities in Physics and Applied Mathematics faculty members of this unit are engaged in teaching various courses of the Institute and other universities and also in guiding research students.

Major topics of research are :

1. Topological field theory, Berry phase, Quantum Hall Effect, Superfluidity, Quantum cosmology, Skyrmions.

2. Quantum field theory in flat and curved space time.

3. Quantum mechanics of anyons including supersymmetric quantum mechanics, q-deformed quantum mechanics. Quantum optics, confined system.

4. Quantum mechanics and Quantum field theory by Stochastic quantization approach. A quantum field theory of dissipative systems, Blackhole Physics.

5. Primordial Universe, Fluctuation of Maxwell Vacuum.

6. High energy phenomena : The problem of baryonic dictatorship at high and ultrahigh energy, inter mittancy phenomenon, Properties of correlation phenomena amongst the secondaries produced in high energy collisions, charge-neutral ratios, underground muon flux, anomalies related with photoproduced showers.

7. Astrophysics : Neutrino energy spectrum, magnetic field decay in pulsars.

8. Solitary waves in plasma, and Dusty Plasma.

9. Rapid distortion theory and coriolis rotation on a turbulent flow. Modelling of turbulent flows with nonlinear terms, deductive theory for a homogeneous turbulent flow in presence of helicity, acceleration correlation in turbulent flow. Calculations of turbulence energy spectra, Pressure spectrum.

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

11. Scattering and radiation problems, wave-maker problems, two layered fluid problems, problems with bottom deformation, Integral transforms, Intergral equations, Inventory models.

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

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

14. Multivariable system and control theory, realization, indentification and decoupling of multi-input systems.

15. Pattern forming instabilities, Physics of granular material, Fluid flows, Dynamic systems and Bifurcation theory.

Externally funded project

1. A study of mathematical techniques in water wave problems

This CSIR funded project is concerned with various mathematical techniques which are useful to handle some water wave problems within the framework of linearised theory of water waves. Study of a few problems has already been completed, and these have been prepared as research papers some of which are published in mathematical journals.

2. Unsteady surface water waves in ocean

This UGC funded project is concerned with investigation of unsteady motion on the surface of an ocean generated due to various types of initial disturbances. The initial disturbances may originate at the free surface or at the atmosphere or at the bottom of the ocean.

Large amplitude ion and electron acoustic solitary waves in a relativistic plasma

Solitary waves in relativistic plasma will be studies in this DST funded project taking into account finite temperature and electron inertia, this study will be extended to Double layers with or without magnetic field.

Biological Sciences Division

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

Agricultural Science Unit

Research activities of the unit are mainly conducted in two different ecological regions, mainly Giridih region of Bihar plateau and Sundarban coastal region of South Bengal. The unit conducted eight ongoing and one new internal research projects and one externally funded project during this period. Farm based studies were carried out in Giridih Experimental Farm with the main thrust on 'increasing cropping intensities and productivity through rainfed farming'. The studies included the following projects :

1. Sustainable cropping system studies

Field experiments were carried out in the experimental farm at Giridih, on certain crop sequential, intercropping and mixed cropping studies, with paddy, maize and groundnut as kharif crops followed by toria, lentil, linseed etc. as winter crop. The results revealed that Groundnut had good potential as an alternate or an intercrop combination with rice where follow up winter crops produced reasonably optimum and stable productivity. Combinations having potentials are groundnut – linseed or groundnut + Rice – Linseed where at least one irrigation was needed during winter crop establishment stage for optimum yield and return. Similarly trials indicated good potential of indigenous rock phosphates as compared to water soluble source of phosphate, in gradual phosphate release and plant uptake as reflected in rice yield improvement over years.

2. The studies on intercropping trials finally established that rice+pigeonpea and rice+soybean are the two best intercropping combinations where productivity could be increased upto 15-20 percent. Another

combination of rice+groundnut also showed better performance in yield. However, blackgram and greengram were noted to be inefficient with rice combinations. Pigeonpea based intercropping with greengram, groundnut and maize indicated increase of yield up to 35% over sole cropping. However, maize being an exhaustive crop, attempts should be to grow in it combination with legumes to restore soil fertility status. Yield and different competition indices also confirm the above conclusion. On intercropping trials, one Ph.D. thesis work is under progress.

3. Crop/Varietal performance

This project was initiated in 1989. In a rainfed farming system, selection of cultivars/varieties, is a very important criterion. With this in view, released hybrids and improved selections suited to different management practices were studied so that a good varietal recommendation with a set package of practices could be evolved. Some results have already been achieved. For upland situation, two varieties of maize, one variety of groundnut and one variety of pigeonpea have been found well suited in the region. A few short duration rice and pulses demonstrated higher land and water utilization potential when grown as intercropped components with long duration ones. Kulthi (minor pulse) and niger (oilseed) can be cultivated as follow up autumn crops after harvesting of short duration rice or maize on mid-upland situation. Jute as a seed crop on marginal eroded lands, offers scope of its introduction. Grain amaranth and winged bean, the two unconvenional protein rich crops, have shown their enormous potential in relation to productivity in this region. On totally eroded rocky upland situation, Sisso (timber) and Cashewnut have shown their potential. Further studies on these lines are in progress. This year emphasis has been made to find potentials of introduced crops and varieties on the basis of sustainable productivity under varying rainfed condition on eroded soil.

4. Work on Palmae

The project was initiated in 1984-85, with the aim to study the various aspects of the members of the family Palmae. The study includes developmental morphology, anatomy, floral biology, development of endosperm in fruits, estimation of production of phloem sap and its minerals and other nutrients, ecology and conservation. Interesting results were obtained from this study. Internal and external structures of leaves, stems and roots of seedlings and adult palms showed significant differences. Developmental study of stomata and trichomes of leaves of four species of palms were studied for the first time. A positive correlation was established between the length-width ratio and specialization index based on end wall characteristics of vessel elements of roots. A study on the effect of phyllotaxy on leaf epidermal characteristics revealed that right spiraled Areca palms possess higher statistically significant number of stomata than the left spiraled palms. In another study on the phloem sap-flow on sugar-yielding wild date palm Phoenix sylvestris, it is revealed that about 35 kg of palm jaggery can be obtained per tree, per season. The value of the jaggery per hectare per year was estimated to be Rs.133980.00. Further study on the development of stomata, trichomes, floral biology, ecology and conservation of different palms is under progress.

5. Introduction of Oil Palm and high yielding coconut cultivars in the Sunderbans area of West Bengal

The project was initiated in 1986 in collaboration with the Department of Agriculture, Government of West Bengal, with the objectives finding out of the possibility of introduction of oil palm and to select the most high yielding coconut cultivars among the well known varieties from Kerala, suitable in the Sundarbans area. The oil palms ("Tenera" variety) established well and started flowering at the age of four years, but stability in fruit yield has not yet been reached. Growth data in respect of number of leaves, height and girth of each plant, and number of male and female inflorescences are being collected at regular intervals. For coconut cultivation, eight cultivars were subjected to field trials, out of which five are tall and three are dwarf varieties. Most of these cultivars were collected from CPCRI, Kasaragod, Kerala. The dwarf cultivars started flowering at about four years of age, and some tall cultivars at the age of seven years. Regular growth data collection and application of recommended dose of fertilizers are being continued.

6. Eco-floristic and anatomical investigations on mangroves of Sundarbans

The project was initiated in 1989, with an attempt to prepare a comprehensive account of the mangrove plants of Sundarbans with respect to their floristic survey, morphology of seed and seedling,

anatomy of leaf, stem and root, and palynology towards understanding of their correlation in taxonomic and elucidation of the taxa. The results obtained so far indicate some important anatomical peculiarities such as presence of colourless water storage tissue at different level of mesophyll, short tracheids at the vein ending, sclereids of various shapes, salt glands, and absence of sclerotic vascular bundle sheath. These features may be interpreted as adaptation to climate and habitat. Vessel elements of mangrove woods are mostly with simple perforation plates except in the members of the family Rhizophoraceae. Definite annual growth rings of wood are absent in mangroves. Pollen morphology of mangroves reveals a heterogeneous assemblage of pollen characters. Seeds of different mangroves show four patterns of germination. During this year, wood and leaf samples of different mangroves collected from Bhitarkonika mangrove forest of Orissa are being anatomically studied and compared with the samples of some species from Sundarbans. This may reveal some anatomical variation due to different ecological conditions. One staff member of the unit has submitted Ph.D. thesis on the basis of work carried out in this project.

Subsistence farming studies of Bihar plateau region

This project was initiated in 1993. Bihar plateau is characterised by undulated low moisture retentive, nutrient deficient and highly eroded acid lateritic soil where subsistent farming system under rainfed condition is a general phenomenon. A thorough understanding of the villagers' choice of crops and cropping system as also their perception of development are some essential prerequisites before transfer of technologies to resource poor farmers. Studies which have already been made, reveal that more uniform rainfall distribution occurs on forest areas with less variation in total quantum. Farmers have own perception of resources and they use low land for their traditional systems of cultivation. Short duration paddy varieties are in great demand for medium land cultivation. Moisture retention pattern suggests enormous potential of medium land for rainfed sequence cropping. Agriculture in this area is based only on food crops which is unsustainable and should be supplemented with food, fodder and fuel based systems. This year the household data collected for the study will be analysed statistically. One Ph.d. thesis will be submitted on this work.

8. Weed crop interaction

This project was initiated in 1993 with the aim to study types of weeds, their interaction with the crops, and to evolve a composite system to control weed problems in the upland soil conditions of Bihar plateau. Results obtained so far on different trials of intercropping such as, paddy with blackgram, and wheat with bengalgram indicate that intercrops could suppress the weed considerably without diminishing the principal crop yields. Medicago sp., a leguminous weed of winter season which was allowed to grow along with wheat, suppressed all other weeds. The yield of wheat remained unchanged. Further work is in progress.

9. Food grain damage by rodents

This is a new project, initiated in April 1995. Rodents are one of the most important biological agents causing considerable losses of agricultural products, particularly food grains. Data on estimation of losses from different Government and non-Governmental organisations are highly variable, ranging from 2.4% to 42%. Considering these widely variable data, it is contemplated to attempt reliable quantification of yield loss of paddy due to rodent. The project work is divided into two parts :

a) Estimation of food grain losses - This work will be extended both in Kharif and Rabi season, and

b) Rodent population study, where 'Lincoln Index' method will be applied.

Some data have already been collected on damage of paddy clusters in the field with the objective to study the affinity to rice varieties, if any, by rodents. Work in this line is in progress this year..

Externally funded project

Livelihood sustainability in Eastern plateau region : Cropping strategies, Knowledge Systems and Environmental Stress

This project, funded by University of East Anglia, U.K., has been initiated in November, 1994. This long term project is to be fully financed by the overseas Institution. First phase of the work, has been completed

in March, 1996. This phase attempted to study the decision making processes of households in degraded plateau areas. Field sites were in Giridih and Birbhum districts of Bihar and West Bengal respectively. Approach is to make micro level study of the resources and their utilization pattern as affected by caste, ethnicity and gender as also local institutional pattern. Field survey is completed and now data are being analysed. We hope to submit the report of the first phase within this financial year.

Anthropometry and Human Genetics Unit

Faculty members of AHGU are engaged in active research in different areas of Biological Anthropology and Human Genetics. The details are as follows :

Projects 1-5 are being conducted within the general framework of the Human Adaptability Programme.

1. Health Status and Labour Productivity

In developing countries, people poorly aided by modern technology, are often required to perform hard and prolonged physical labour, in order to fulfil the basic needs for survival, e.g., food, shelter, etc. Therefore, manpower serves as an important factor in production and subsequently in creating favourable living conditions. It is intuitively understood that health status plays an important role in determining labour output and these relationships have been also revealed from the studies conducted outside India. The studies on these relationships are scanty in the Indian subcontinent. In view of these, the present project was undertaken among the Oraon agricultural labourers to find out such relationship, if any.

Very small amount of demographic data have been analysed, which suggst that both fertility and mortality are lower in case of Oraon agricultural labourers compared to Oraon tea garden labourers of the similar geographical area, and anthropometric data suggest a poor health condition of the agricultural male labourers compared to male tea garden labourer, but the picture is reverse in case of female Oraon labourer.

Systematic studies of health status and labour productivity in different occupational/ethnic groups could be utilized and linked with many health related studies, involving the biological and socioeconomic consequences and determinants of individual and population health status. These data also could be utilized for the potential success of population specific economic and health programmes.

2. Effects of Micro-Environmental Factors

The study aims at studying the effect of microenvironmental factors, e.g spatial/physical environmental, economic, social, ethnic, etc. on health and nutrition related traits. These are all planned to be studied from the human adaptational point of view.

Systematic studies on the effect of microenvironmental factors on health and nutrition related parameters are meagre. The present study would be useful for organising and planning of different health and nutritional programmes.

3. Women's Stidies : Health and Well-being of the Child, Adult and the Elderly

The present project intends to evaluate the health status of females in their three phases of life, e.g. preworking age, prime-working age and post-working age. Work among the preworking age group could not be started yet. Data are being collected from prime and post-working age groups. A considerable amount of data have been collected from the post-working age group of women engaged as college teachers in Calcutta. This group has been divided into two broad age categories - one between 50-60 years while the other above 60 years (age 60 being the age of retirement has been taken as the cut off point).

The anxiety scores of these women have no correlation with their ages, years of work and number of child(ren).

4. A study on the Determinants of Fertility and Mortality in an Urban Setting

The overall hygienic condition is better among the Hindus compared to the Muslims. The study also shows that institutional birth is more among the Hindus than the Muslims. Home delivery is very high among the Muslims. Traditional birth attendants (Dai) are Hindus and are engaged by both the communities.

The air-borne, water-borne and other infectious diseases like measles, chicken pox, dysentery, malaria, tuberculosis, pneumonia are common in both the communities especially among the Muslims. The allopathic treatment is the usual practice but occasionally homeopathic and ayurvedic treatments are also sought. Supernatural belief regarding disease and folk treatment are also found among both the communities especially among the older folks.

Immunization and periodical health check-up cases are more among the Hindus than among the Muslims. About 20% of the children are solely breastfed upto 25 months. Supplementary foods are initiated from six to thirteen or above months. Acceptance of modern family planning methods is higher among the Hindus than the Muslims. The Muslims are in favour of traditional (natural) methods of F.P. like rhythm, coitus interruptus, periodic abstinence, herbs, etc.

The Muslim parents are not careful about their children (child neglect). The overall status of women is low in the Muslim than the Hindus and that practically the Muslim women have no role in decision-making even in the matter of her own reproductive life.

The health seeking behaviour between the Hindus and Muslims is different which affects the morbidity pattern. In general, both the communities are reluctant about utilizing the available health structural facilities (like government hospital) due to the negligence and lack of sympathy on the part of the government doctors and the unavailability of medicine in the government hospital. The overall surrounding is very unhygienic and polluted. Overcrowding is the main problem which affects morbidity.

5. Modernization and Health in the Sikkim Himalaya

The objective of the project, initiated in 1995-96, is to examine the relationship between individual modernity and health characteristics (assessed in terms of selected measures of observed and self-perceived morbidity) among the Bhutias, a tribal population of Sikkim.

It is envisaged that a systematic study aimed at detecting socioeconomic and other environmental factors associated with modernization that affect health/morbidity characteristics of individuals belonging to a tribal community exposed to varying degrees of modernization, may help formulate appropriate and realistic community health programmes.

6. Genetics of Dermal Ridges

The research in the area of dermatoglyphics (toe, sole, finger and palm) mainly involves bilateral asymmetry (directional and fluctuating) and pattern of inheritance. The study aims to evaluate : (1) Genetic and common family inheritance components of toe and sole in addition to finger and palm; (2) Genetic component and phenotypic relationship between toe and finger, sole and palm as well as between characters within the palmar and plantar dermatoglyphics; (3) Ethnic and sex variation within and between population groups as well as in genetic disorders and on twins; (4) Examine asymmetry of some bilateral anthropometric dimensions and their association with dermatoglyphic asymmetry.

7. Growth study of the Bengali Children

Analysis of Body mass Index (BMI) data of the Bengali boys have been undertaken to see distributional properties, changes during the period of growth, correlations with a number of measures of body composition (upper area muscle and fat areas) and with the measures of shape and indices that are hardly available for any Indian population so far.

Reanalysis of family data of anthropometrics have been partly completed.

8. Genetics of Complex Traits

Genetic analysis of complex diseases has been the major focal theme of the research. By carrying out statistical analysis of data on pedigrees, we were able to provide further support to a multilocus recessive model for vitiligo that was earlier proposed by us.

Studies were initiated to identify and to estimate the nature and extent of epistatic interactions among loci in the beta-globin gene cluster. For this purpose, a molecular genetics laboratory has been established and standardized. Blood samples were collected from families residing in a geographical with a high prevalence of the sickle-cell gene. Analyses of the blood samples (haematology, red cell morphology and PCR analysis) have been completed.

9. Human Ecology

(i) The changing patterns of resource use and its cultural and biological implications are being studied among a Kuki tribe called Gangte, who are currently living in the hills of Manipur and are undergoing rapid transition from shifting cultivators to the urbanized mode of subsistence.

The results obtained so far suggest general improvement in the economic situation and literacy and reduction in child mortality. A trend of decline in the availability of biological resources and increases in admixture with non-Gangtes is also apparent.

Statistical analyses of different data sets collected earlier are being pursued. As part of this, we have so far synthesized all-India data on (1) the inbreeding effects on reproductive outcome, and (2) finger ridge count variation of the Indian population. We have also analysed (1) genetic differences between migrant populations and their parental counterparts, (2) effect of life styles on blood pressure variation, and (3) dermatoglyphic and anthropometric affinities of some local clusters of populations, in the light of ethnohistorical and geographical backgrounds.

10. Population Structure and Human Variation

Human impact on biodiversity, interface between forest dwelling communities and forest resources.

11. Genetic Epidemiology of Rheumatoid Arthritis

A family survey in Nadia District has been completed. Clinical tests and blood investigations have also been completed.

12 Human Population Variation

A few rare variants have been observed in the following systems - G6PD (slow), 6PGD, AK_1, PGM_1 and MDH.

13. Epidemiological and Clinical Studies

Epidemiological profile data on Diabetes have been collected through family studies on Bengali Hindu population by enumerating the number of persons belonging to a Municipal Corporation/Panchyat Wards in three habitats : Rural (471 families), Industrial (487 families) and Urban (561 families). Analyses of primary data and confirmation of disease status are in progress.

Surgically incised organs - Appendix, Gall Bladder and Hernial Sac collected on Hindu Bengali individuals have been analysed to study histopathological and genetical changes.

1. Cancer Chemoprevention : An Approach Towards Cancer Control

Following projects are ongoing on Uterine Cervix Cancer Prevention.

(a) A highly sensitive and specific antibody against folic acid has been obtained by coupling folic Acid with E-amino caproic acid modified bovine Serum Albumin. Using this antibody an ELISA method for multivitamins formulation and for human serum have been developed. Serum from various cancer and precancerous subjects are under investigation.

(b) A case control study was performed in order to assess whether folic acid levels have any significance under the pathological condition of malignancy. Cases (M) with established malignancies (males and females) and two groups of controls, normal controls (N) with no known history of ailments including malignancy; and non-malignant control (NM) with no known history of malignancies, but with other ailments were selected. The study indicates that a ratio of folic acid to total folate may have the potential to serve as an aid for the assessment of a pathophysiologic condition such as cancer.

(c) The tissue culture laboratory has just been completed and the cell culture related work has begun.

2. Mechanism(s) of Resistance to Oxidative Stress in Cultured Chinese Hamster V79 Cells

The involvement of oxidative stress in various diseases such as cancers, aging and other degenerative diseases has been well established. The mechanism of action for this is investigated by various groups of investigtors. The present programme is exploring various oxidative stresses using a model cell culture system.

A methotrexate (MTX) resistant cell-line M5 was initially isolated by exposure of V79 cells to UV light and subsequent selection of MTX. This cell line showed similar phenotypic response (resistence) towards oxidative stress (challenge by H^2O^1 and or gamma rays) as the parental V79 cells in which low dose of H^2O^2 induced repair function was operative.

The present proposal aims at characterization of the radio/oxidant resistant phenotype of both the V79 and M5 cells with respect to the role of glutathione and glutathione - metabolizing enzymes at the biochemical and genetic level. Special emphasis will be given on exploring the role(s) of apoptosis (programmed cell death) in the mediation of resistence to oxidative stress (s) in V79 cells and how is it affected by modification of the glutathione cascade at the molecular level.

3. In Phase II of the genetic epidemiology of blood pressure study (in collaboration with AHGU) 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 family is that there should be at least one hypertensive patient (proband) in the family. During past year dietary and biochemical estimation of blood sugar, serum-urea and total cholesterol, lipid fractions were done on 500 subjects. Special nutritional data on each subject including family has been started currently. These will be utilized in order to find out whether any dietary risk-factor(s) can influence the development of hypertension.

4. Analysis of buccal mucosal epithelial cells from pan and khaini users focussed that the frequencies of karyolytic, pycnotic and micronucleated cells were estimated in 55-60 subjects during the year. A relatively higher incidence of the above indicators have been noted amongst the 'Khaini' users along with local ulceration compared to the 'pan' chewers. Occasional appearences of these abnormalities were noticed in control samples.

5. A collaborative project has been initiated with Bengal Veternary college, Kalyani, on exploring the non-volatile and volatile pheromones and their lipid fixatives, if any, in the vaginal secretion of goats.

The primary aim of the present phase of the ongoing project on chemical communication of big cats is to investigate the chemical nature of Marking Fluid (MF), the putative source of pheromone of Cheetah (Asinonyx jubatus). Samples were collected from Africat foundation, Otjiwarongo Farm, Namibia. Comparison

of chemical constitutents has been made between the two mammals (cheetah and tiger - Panthera tigris tigris) belonging to two different genera. Evolutionary significance is being analysed depending on the above findings.

Embryology Unit

The Unit has been engaged in carrying out the following ongoing projects.

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

Mechanism of spontaneous pattern generation and emergence of ordered structure through self-organisation has been further studied with special emphasis on the analysis of spatial structure and spatially variable membrane properties. Mechanism of carcinogenesis have been further investigated with the help of reaction-diffusion mathematical and stochastic models by introducing the idea of activator and inhibitor of cellular growth as well as contact cell inhibition of mitosis. Numerical and computer analysis of the non linear mathematical models with or without time delay are in progress. Two students have obtained their Ph.D. degrees under the supervision of the project leader Prof. P.K. Tapaswi.

2. Intercrop interaction - a mathematical study of agricultural ecology

Allelopathic interaction through root exudates (RE) of different varieties of rice and wheat and between different crops has been investigated. Study of the composition and properties of the allelopathic agents in RE such as phenolic compounds, aminoacids and fatty acid detected earlier has been further pursued with the help of GLC, UV spectrometric and MS analysis. The allelopathic effects of certain weeds, plants and fruit pulp have also been investigated. A mathematical model of nutrient diffusion through soil and its effects on the growth of seasonal plants has been proposed. Two students are doing Ph.D. in this project under the supervision of the project leader, Prof. P.K. Tapaswi.

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

Model based studies of embryonic development have suggested that (i) any existing pattern within the embryo can be altered by imposing the pre-assigned gradient; (ii) there exists two gradients namely, (a) morphagen gradient in the form of concentration and (b) the pre-assigned gradient in the form of signal. During development gradient (a) will vanish, implying that there is no need of positional information after getting a final pattern but gradient (b) continues to exist which implies that the latter is responsible for large scale/global pathway for the future development of the embryo. Some works have also been done on the functional and structural aspects of amino-acyl t RNA from a physical point of view.

4. Mathematical epidemiology

Mathematical and stochastic models of Japanese encephalities, measles and different vector borne diseases have been further studied with special reference to seasonal fluctuation and spatial spread. The susceptible-infected-recovered (SIRS) models with immunity boosted by subclinical infection have been further explored. Host parasite models have been further improved by considering the immunity rendered by infection with parasites and investigated. An SEIR (susceptible exposed infected recovered) model of measles has been proposed and analyzed in the context of a case study.

5. Diffusional effects on two or more interesting species in community ecology

The importance of differential species mobility by considering environmental and temporal heterogeneity has been taken care of. by considering an ecological model for predator-prey species in which the dispersal rate is space dependent throughout the domain, it has been shown that for any such system there exists a unique scalar function C(X). Different values of C(X) in different space regions result in the appearance of simultaneous subpatterns within the domain that may well be mutually in sharp contrast. The essential role of C(X) on the stability aspects of a general two-component system has been investigated. In fact, C(X) may be taken to characterise any large scale assembly of differential substructures. The effect of seasonal

fluctuation in prey-predator system has also been investigated. By using Floquet theory, we have shown that variable diffusivity in prey-predator system makes the system more stable than rendered by constant diffusivity.

Leaf Protein Research Unit

Work has been pursued on the following aspects :

1. Thorough chemical, biochemical and nutritional analysis of water weeds it was indicated that a few species could be used directly as vegetables while some others could be exploited for leaf protein extraction. Extracted protein was evaluated by rat experiments. A combination with wheat flour proved to be balanced enough to give results of 2.1 to 2.2 PER values in comparison to 2.4 by casein. Aquatic plants also proved to be efficient uptakers of nutrients from water bodies. These results are forming a base for planning futuristic studies.

2. Similarly, tree leaves were studied with the thematic base being to make them worthy as a feed source. Reduction in toxicity in fibrous fraction, as the main product, was of the primary concern. Extracted protein being the byproduct - because protein content and extractibility were lower than crop plants - was assessed in chick assays. 25% of a basal protein i.e. soya protein was replaced successfully. Conversion of protein to body weight at 40% was very interesting. Fibrous portion could replace 50% of bovine feed successfully. Thorough chemical and biochemical analysis of fibre was done.

3. In sugarbeet, optimum fertilizers were worked out (N in the range of 120-140 kg/ha and k at/around 100 kg/ha). Pattern of reduction in percent of sugar with advance of harvesting time was checked by k fertiliser. 12-12.5 t/ha yield of sugar was achieved. Work on technological aspects exploiting solid phase fermentation to achieve good quantities of ethanol and pectin has been done. Experiments to achieve efficiency in recovery percent of ethanol and charactrization of pectin are currently going on.

A significant amount of good quality protein was extracted from the crops. Economic feasiblities with maximum end products will help to set the strategy of exploiting the real potential of the crop.

4. In lab to land programme - acceptability for tablets or powder form, incorporation in recipes at 5-6% was studied. 90% acceptability was achieved. Practicality by designing prototypes at village level was demonstrated. Two long term feeding trials laced with literacy, hygienic improvement were conducted. Economics of production at rural base for each fraction and the technology as a whole are under study.

5. Lignocellulosic jute wastes, viz. leaves, stick and caddis generated in large quantities from jute cultivation and industry were used as substrates separately and in admixture with rice straw in 1:1 ratio for production of edible mushroom Pleurotus sajor caju. While growth of mushroom mycelia were hindered on jute leaves, jute stick and caddis separately and as mixed substrates with rice straw were found to produce the mushroom in good yield. Use of fibrous by-product left after leaf protein production as well as some crop residues in preparation of medium density particle board is in progress. The interesting feature noted about the physical and mechanical properties of the prepared boards from lignocellulosics is that no effect of method of preparation (UF and In situ method) was found as also on the properties of prepared particle boards except on physical properties like moisture content and absorption of water on volume basis (after 2 hours) and mechanical property like tensile strength perpendicular to surface.

6. 100 soil samples from different alluvial zones were screened for prospective proteolytic (gelatin liquefaction) and lipolytic (olive oil hydrolysing) microbe. For proper identification cultural studies are going on (utilisation of sugar and nitrogen source). A number of physical chemical and structural properties of coastal alluvial soil have been studied.

Social Sciences Division

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Planning Unit, Populations Studies Unit, Linguistic Research 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 this 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

The research work done during the year under review covered, broadly speaking, different areas of theoretical and applied economics and econometrics. Some of the major areas in which researches were done are given below :

1. Economic development and macro-economic policy in India : Some analytical works in this area have been completed. These include issues in financial liberalization, role of money, credit and government finance, budgetary policies etc. Studies on the patterns of inter-regional development in India, growth of service sector in India during the period 1960-90 were also undertaken during this year.

2. Economic Theory : Research works on various areas in economic theory are being done over the last few years. Mention may, in particular, be made of economic efficiency, welfare economics and industrial economics.

3. International trade : Researches are being carried out to examine the effect of foreign investment in output and employment in a developing country like India where the size of the domestic market is large. Some studies on the effect of protection on exports have also been done. These are being further investigated. Mention may be made of another study which focuses on co-operative and non-cooperative R and D behaviour of competing firms as also of joint ventures.

4. Agricultural economics : The existence of several interlinked parameters (such as tied wage, share of output, interest rate etc. which are tied with the incidence of private credit market in the rural areas) as the dominant feature of the Indian agrarian economy is very well-known. Furthermore, these parameters very often alter the marginalist principle of allocation of inputs in the farmer's decision-making process. Some theoretical attempts to identify some of these parameters and to analyse their mutual interactions within a broader framework of firm efficiency study have been made during the year. Another study focuses on the relationship between the agricultural price seasonality and market arrival seasonality of wheat and rice.

5. Econometric Methods : Some of the topics on which research in econometric methods were done are : (a) hypotheses testing in non-regular cases, (b) autoregressive conditional heteroscedastic (ARCH) model, ARCH-M model, ARCH-M and Box-Cox transformation, and (c) cointegration.

6. Studies on consumer behaviour and level of living : The methodological study on the estimation of Engel elasticities of clothing and other items based on NSS 38th round household budget data was continued during the year. Interesting results were obtained by applying instrumental variable method of estimation to last month data with a view to overcoming the difficulties arising due to seasonality and other transitory influences.

As a part of the research project on strategies and financing for human development sponsored by the Goverment of India and UNDP, some faculty members had taken up a project entitled "Employment, level of living and utilisation of public distribution system". The project was completed during the period under review and the report was duly submitted.

Work on studying the trends in the extent of inequality, poverty, agricultural growth, rural-urban disparity in the level of living in India, absolute level of living, poverty and deprivation continued during the year.

7. Other econometric applications : Some of the areas in which researches were done relate to (a) measurement of child cost, equivalent scales etc., (b) optimal commodity taxation, (c) employment fluctuation/uncertainty, (d) non-parametric demand analysis and (e) causality between social development and economic growth.

Economic Analysis Unit (Bangalore)

The unit is actively engaged in research on Growth, Variability and Stability of cereal crop yields in India, Bayesian Analysis of Forecasting, Monetary Policy in India, Measurement of Poverty, Trade Liberalization and Game Theory. The major topics of research were :

1. Agricultural Trade Liberalization Strategies : Growth, Welfare and Large Country Effects.

2. Growth, Stability and Variability of agricultural crop yields in India and Andhra Pradesh.

3. Measurement of Poverty without a Poverty Line.

4. Liberalization of trade in agricultural commodities in Developing countries - Experience with Tea Trade of India, Sri Lanka and Kenya.

5. Matrix Games with Random Pay-offs - A Curiosity explored.

6. New Evidence on Production Smoothing Hypothesis.

7. Impact of uniform priors on non-linear parameters : A simulation study.

8. Exploratory Bayesian Analysis of Modelling incomes : A case study of Italy.

Work on a UNDP/GOI project entitle "Government Operations in Foodgrains : Research project on strategies and financing of human development" was also carried out.

Planning Unit (Delhi)

The Planning Unit conducts social science research in both theoretical and applied areas. Though the major focus is on economics, other areas of social sciences are also covered. Theoretical work includes game theory, planning porcesses, environmental economics, public economics and financial markets. Applied work includes studies on inflation, agriculture, restructuring of industries, poverty measures and banking.

Linguistic Research Unit

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, Social Linguistics, Syntax and Text Analysis. The details are given below :

1. Quantitative Linguistics : Efforts are on in collaboration with Trier University and Ruhr University, Germany, to expand the research on text analysis. Attempts are being made to develop a programme system for the analysis of texts in Indian languages. An English and German version of IRM (Intext Results Manager) is currently available to users. Their adaptability in the Inian context is being experimented with. Studies are underway to examine the statistical structure of texts and its readability. Quantitative characteristics of texts as a whole and its relationship with text readability are being studied keeping in mind the polysemantic nature of the term "text readability". Collaborative research is continuing with linguists at York University in the area of language attitudes from the prespective of language maintenance. The work on Natural Language Processing in the Unit mainly follows the surface syntactic theory propounded by Xoldovic and Tesniere in contrast with Generalised Lexical Functional Grammer (GLFG) tradition followed by other Indian linguists and computer scientists.

2. 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 Telugu as L1 were tested in Hyderabad using the Kostic, Mitter (1982) test for articulatory evaluation of Telugu speech sounds. Preliminary analysis showed results similar to that of the Bengali subjects in that the performance of the

subjects varied according to the group they belonged to. Obviously Group IV subjects who had a fairly good perceptible hearing range performed better as compared to Group I or Group 0 subjects who have very little or no hearing remnants at all. The age of onset of hearing loss, the criteria upon which the groups were further sub-classified was also found to be important as subjects with congenital hearing loss had very poor articulation as compared to those subjects whose hearing was affected during the language acquisition period, probably due to severe illness. The usefulness of the Kostic classification in the isolation of subjects who can be identified with a certain group can go a long way in monitoring an appropriate habilitation programme for them. After this we wil be testing a group of 50 Hindi speaking hearing-impaired children in order to generalise the findings obtained for Bengali and Telugu.

3. Comparitive Suprasegmentals of the Slavic, Indo-Aryan and Dravidian languages : The stress patterns of 60 isolated Hindi disyllabic words containing combinations of long and short vowels were studied. In order to analyse whether the length i.e. duration of syllables is a significant one for the presence of stress in Hindi words. For this study 20 subjects allnative Hindi speakers were teste. The main aim here is to study the consistency of the occurence of stress in dysyllabic morphemes. Similar data were collected from 20 native Bangali speakers to study the difference in duration and frequency of similar lexical items from the two languages in question. The data are being analysed on the Visi-pitch (6087DS). The role of juncture in coarticulation was studied in greater detail by analysing the rest of the data collected from 50 Bengali speakers. Syllable stress was also studied in detail by collecting fresh data from a larger sample size from Telugu, Tamil, Oriya, Hindi and Bengali speakers residing in and around Calcutta.

Population Studies Unit

The broad areas of research of the Unit Include,demographic and epidemiologic transition in India, development of disability statistics and indicators, proximate determinants of fertility, demography of West Bengal, bias and sampling variability of fertility estimates etc. Some of the researches are described below :

1. Sub-national comparisons of disability indicators : Patterns and levels of disability are studied across four geographic regions. For the first time a few disability indicators in the form of disability-free life expectancy (DFLE) are calculated for India. DFLEs are derived both in terms of overall physical disability and separate dimensions of visual and locomotor disabilities.

2. Health and demographic transition in India : The study is being conducted to make full use of existing sources of data to illustrate socio-demographic and health profiles of ageing in India. While constructing models of mortality, account will be taken of the whole process of a disease, including development, being cured, relapsing again, progressing, and finally leading to death. Indices of mortality and morbidity are being generated in order to document the nature of health transition. A pilot household survey on cost of health care for the people aged 50 and above has also been conducted. A draft report of the study is being prepared.

3. Socio-economic determinants of achievement of primary level students in West Bengal : In the present study, scholastic achievements of primary school children at the end of class IV and their co-variates are examined. The two-parameter logistic model is adopted for construction of tests. According to the model the probability of giving correct response to any item i by a student with skill x in the subject is given by $P_i(x) = P(u_i = 1/x)$, where u_i is a binary variable denoting the item response. The ability of examinee j is estimated by

$$x_j = \sum_{i=1}^{n} a_i u_{ij}$$

where u_{ij} is the item response score of j in item i, a_i is the parameter of item i estimated from the item characteristic curve for the present model and n is the number of items in the test. The study was presented in a "Seminar on School Quality in India" organised by the National Institute of Educational Planning and Administration, New Delhi, in 1995.

4. An enquiry in to the quality of life of five communities in West Bengal : 1994-95 : At the instance of the West Bengal Backward Classes Commission, the study was undertaken to address the issues of social, educational and economic levels of some communities in West Bengal.. The treatment of various issues is historical-cum-analytical. Besides the qualitative aspect of social issues, some quantitative indicators have been considered for an examination of differentials in the quality of life among the groups studied. The completed report has been submitted to the WB Commission for Backward Classes.

5. Maternal Mortality : An International Perspective with problems and Prospect : An indirect approach is proposed in the analysis to find the estimates of maternal mortality ratios in the rural areas of the different states in India. When maternal mortality ratios showed some development from the rural areas of some states in India then others were lagging in this regard.

6. Micro Regional Statistical Surveys in India upto 1875 - An Evaluation : During the British rule in India extensive surveys of various kinds were conducted for collection of quantitative materials of the territories which the East India Company acquired either by conquest or by cession. The objective of the project was to collect the reports of the earlier surveys and to examine the materials supplied by them to prepare a list mentioning the year of survey, the name of the surveys, territories covered by the surveys, the sources of the document on the survey and the statistical information thrown by the surveys.

7. Cost and Economic Benefits from Child Labour in Agriculture Sectors : This research is based on one thousand households selected from rural areas of two districts of West Bengal. Findings from this research will throw some light on the following issues : (i) the cost of rearing a child and the economic benefits if provides to the family as an agriculture child labour (main or marginal workers) ; (ii) whether the family size is inversely related with the cost of rearing the child, and (iii) whether the family size is directly related to the agriculture child labour (main or marginal work) because of economic benefits.

8. Population Dynamics of West Bengal : A rapid population growth has been the major concern of the state of West Bengal, in particular and for all the developing countries, in general during the last four decades. The state of West Bengal, to a less extent, has increased its industrial, and, to a greater extent, its agricultural productivity, but no possible increases could result in the permanent amelioration of living condition of the peopld in the state because of high rate of population growth. In view of this, the components of population change (fertility, mortality and migration) have been estimated because these components are dynamic in nature. Levels and age-patterns of fertility as well as mortality have been estimated. Due to paucity of migration data, estimation of migration has been ignored. Furthermore, NFHS data will be used to substantiate the results obtained from census and Sample Registration System (SRS).

9. Inter State Male Migration in India : To study spatial movement of male population in India, transition matrix of inter state male migration has been built up for 1961-81. Immobility or less mobility is the characterising feature of Indian male population. Whatever mobility has taken place, it has been confined to short distance mainly. Migration has been most effective in West Bengal, Maharastra etc. Fresh migration rates either positive or negative show negligible effect on growth pattern of population at state level. In migration correlates highly with percentage of population, number of towns, productive capital used, wages paid to workers.

10. Nepali Migration to West Bengal : Nepali migration to West Bengal has never assumed a stams of large scale exodus at any point of time. Nepali migration constitutes less than 2 percent of the total international migration to the state. Nepali migrants tend to cluster mainly in Darjeeling, Jalpaiguri, Calcutta and the 24 Parganas.

11. Maternal Mortality - An International Perspective with Problems and Prospects of Indian Data : This study incorporates various definitions of maternal death. A global perspective of the levels of maternal mortality is described notably from the most under devloped African and some South Asian countries to even most developed region including North America and some European countries. The study also highlights the data scarcity particularly in India where hospital based data are not representative since the majority of deliveries take place at homes. Maternal mortality ratios are estimated for the states of India using proportion of maternal deaths, crude birth and death rates usually obtained from the office of the Registrar General, India in its various publications. The study also touches on the issues on malnutrition, illiteracy and lack of health conciousness and many other social taboos attributable for higher mortality.

Psychometric Research and Services Unit

Research work done by the Unit during the year is briefly summarised below :

1. Potential Entrepreneur School Leavers : The objective of the study is to identify potential entrepreneur from among the school leavers. Data from trainees attending Entrepreneurship Development Programme from different parts of West Bengal have been collected. Data from entrepreneurs, who have small scale manufacturing units, have also been collected. On the basis of these two, an instrument for measuring Entrepreneurship potentiality is being developed.

2. Motivation to work for Primary level workers : The objective of the study is to develop a questionnaire for assessing the motivation level of different groups of workers, Pilot study has been done on a group of 52 clerical workers with a preliminary questionnaire. On the basis of the pilot study the questionnaire has been revised and data from different groups of workers are being collected.

3. Attainment level of the Primary School Children at the end of class IV, for Non-Scholastic subjects : Data had been collected during the year 1991-92 from all the 17 districts of West Bengal. Districtwise scrutiny, coding and scoring of answer papers are going on.

Sociological Research Unit

The scientific workers of SRU have been carrying out their internal and external research projects in areas which have direct implications in understanding the rubric of social transformation. A brief description of these research projects, both internal and external, are given below.

1. A study of the process of religious conflict and convergence in West Bengal : The occasional resurgence of religious intolerence, which was witnessed in some parts of West Bengal in December 1992 along with other regions of the country, requires an in-depth analysis which would involve explication of the current societal stress and strains as well as unfolding of the opposites historical trends of religious conflict and syncretism in Bengal. The analysis would also take into account the variations which have been latent in the religious sphere between the popular rural tradition of Bengal and the heterogeneous urban reactions of the colonial and the post colonial milieu of Calcutta. The study would further include the variations obtaining between the religious tradition of Bengal as a whole and those of other parts of the country which have historically interacted with Bengal. The gamut of above variables are being studied in two different locations in West Bengal - one in East Calcutta and the other in a rural area of Kenduli in Birbhum district - which had experienced religious communal tensions in December 1992. The field work has already started. The document-based source materials on the communal situations relating to both the situations have been collected. The study of the basic texts on different religious traditions of Bengal and their current implications as well as the publications on the recent communal disturbances in different parts of the country have been taken into consideration. A paper on the syncretist religious tradition of Bengal has been published in May 1994 in a special anthology released by Government of West Bengal on the social history of Bengal. Another paper has been published in March 1995 in Social Scientist. A comprehensive report is going to be submitted soon.

2. Agro-sociological constraints of technological adaptation in subsistence farming of Bihar plateau region : This is an ongoing research study in collaboration with the Agricultural Science Unit of ISI. The area of study covers 24 villages in 5 clusters spread over 8 (eight) minicatchments of Usri water shed of the DVC. The focus of the study is to identify the socio-economic relations under which the technologies are being operated by the practicing farmers. Data on farm-size, productivity, input-output, cost-benefit, labour-relations, land-relations, credit-relations have been already collected. Comparative data on alternative cropping strategies would be evaluated in the winter of this agricultural year (between December 1994 and March 1995). A project report has already been submitted.

3. Scope and constraints of rural women leadership with special reference to experimentations in self-government bodies : The study intends to enquire into the (a) social profiles of rural women leadership

and their representation in the Panchayat; (b) initiation of women to the leadership, the motivation and the resultant process in the society; (c) scope and constraints of plying the leadership role in their families, society, among colleagues and other social and political institutions; (d) role and relationship with the male-leaders and their fellow women; (e) question of their gender role in leadership; (f) sense of achievement of women folk in the community and society for having leaders from among themselves; and, (g) level of conciousness and exposure as well as performance of women in leadership position. For a pre-pilot survey, Gram Panchayats of two districts of West Bengal, namely Midnapore and Birbhum, have been selected. Midnapore was chosen because this district has a unique feature viz., here a Gram Panchayat is run exclusively by the women (Kulthikiri Gram Panchayat under Jhargram Sub-division). The other district Birbhum was selected since a long personal research experience was gained previously in the villages under Md. Bazar Block. Thus Sankrail Block of Midnapore and Md. Bazar Block of Birbhum have been earmarked for the survey. Data Collection is underway.

4. Chamars and Santhals of Giridih : In Bihar, Chamars and Santhals are numerous among all scheduled castes and all scheduled tribes, respectively, and they are distributed throughout the State. Besides, it is generally assumed that the impact of urbanization and industrialisation is affected by change, as also by emergence of new type of occupations within umbral zone of such process. Hence, it is expected that Chamars and Santhals will be more influenced by such process, since they have very little to lose by way of social prestige in whatever occupation they engage themselves, being placed in lower rung of the social hierarchy. Data collection is going to be completed soon.

5. Evaluation of Rainfed Farming Project (RFP) : The project was sponsored by the Overseas Development Administration (ODA), U.K., and implemented by Hindusthan Fertilizer Corporation Ltd. (HFCL) in consultation with the Overseas Development Group (ODG) of the University of East Anglia, Norwich, U.K. with the objective to explore the possibilities of low cost sustainable agricultural development, under rainfed conditions using farmers' own resources. The project is system-evolutive, farmer participatory with poverty focus and conceptualised not as a blueprint, but as a process. It was implemented in 6 districts of east Indian plateau region in West Bengal, Bihar and Orissa. Requested by ODA and HFCL, an inter-disciplinary team of ISI undertook a Base Line Survey in 1989-90 and subsequently carried out annual Evaluation Surveys and submitted the reports, to HFCL and ODA.

6. Evaluation of Total Literacy Campaign (TLC) in Calcutta Metropolitan District : Calcutta Municipal Corporation has decided to undertake a programme of TLC in Calcutta. For this purpose it requested SRU to provide its expertise for a Base Line Assessment and work out a programme of subsequent evaluation of the project in order to monitor and raise the efficiency of TLC.

7. Baseline Assessment Study of DPEP in West Bengal : For the purpose of District Primary Education Planning (DPEP) in five districts (Bankura, Birbhum, Murshidabad, South 24-Parganas and Coochbehar) of West Bengal, a Base Line Assessment of learning, comprehension and reasoning was undertaken among students of class II and class IV in randomly selected schools in each of these districts. At the request of Government of West Bengal and ODA, UK, ISI trained selected school teachers for this field survey, supervised their work and analysed the data. A report was prepared and submitted to the Government and ODA. In continuation of this report further requests were made to do in depth studies on retention of learning and dropping out of girl students as well as tribal students and students of minority groups in primary schools. A report based on the findings of Birbhum district has been submitted coveing female students and ST students. Report on minority students and SC students will be submitted later.

8. An enquiry into the quality of life of five communities in selected districts of rural West Bengal : 1994-95 : At the instance of the West Bengal Commission for Backward Classes, a study on the socio-economic conditions of five communities viz., Mahishya, Sadgope, Saha, Tili and Baishnab Adhikari was taken up to measure and identify the degree of their social backwardness. The study was carried out in the rural areas of Howrah, Hooghly, Midnapore, Murshidabad, Nadia and 24 Parganas districts. Seveal indicators - both qualitative and quantitative were used in this study to identify the relative social position of the individual communities. A report based on the results of the survey has been prepared and sent to the West Bengal Commission for Backward Classes in October 1995.

9. Survey of the possibilities and problems of small industries in Birbhum district : West Bengal Small Industries Corporation, Government of West Bengal, has funded this project. The underlying rationale of the

project is that overwhelming majority of rural population in West Bengal depends on land for subsistence. Implementation of land reforms including registration of rights of share croppers and minimum wages for labourers is expected to raise the level of income of specially the rural poor which, in turn, is quite likely to raise demand for various goods for consumption. It is also possible that in some cases surplus will be saved and invested in various enterprises. In short, conditions for expansion of market demand and local investment of these demands are created. However, it may also happen that big enterprises located elsewhere are capturing the newly created market. The objective of the project is to explore facts regarding what is actually happening and assess the possibilities of empowering local entrepreneurship to become economically viable. The study at present undertaken in Birbhum district, will be considered as a model which can be replicated in other districts of West Bengal.

10. In-depth Studies on the levels of Development of Scheduled Castes/Scheuled Tribes : Being sponsored by the Ministry of Welfare, Government of India, this study seeks to assess the present levels of development among the Scheduled Castes and Scheduled Tribes of the Birbhum district by collecting varieties of information on objective and perceptual variables in order to develop appropriate development indicators. The main aim of the study, however, is to evolve appropriate social and economic indicators of development for the purpose of evaluating the development performance meant for the weaker sections of the Indian Society and also to study the differences within the weaker sections and between weaker and the other sections. The study has adopted a design based upon controlled sampling technique with multi-stage deep stratification. In order to be adequately representative, the study has been supplemented by special studies of SC/ST communities in Midnapore, Purulia and Coochbehar districts. The survey of SC/ST households in 70 sample villages of 8 blocks is over.

11. Guidance and consultancy services in data processing : Since 1988, the SRU has undertaken a programme "Guidance and consultancy services in data processing' under the auspices of Indian Council of Social Science Research (ICSSR), New Delhi. The faculty staff of SRU have been providing guidance to Ph.D. scholars from different universities in eastern India. Services have been provided to scholars of various universities of Orissa, Bihar and West Bengal.

Academic activities of Giridih Branch of Sociological Research Unit

In the context of the broad theme of social transformation, SRU since 1958 has been effectively pursuing in Giridih research projects concerning the problems of urbanisation, migration, dimensions of integration in rural life, inter-caste and inter-class relationship in Giridih and surrounding villages, controlled measurement of fertility, application of Mahalanobis's D^2 to social science data on intergroup relations, appraisal of household stocks of handicraft and machine-made products in the villages, exploration in Palamau area to measure the impact of developmental plans on the rural population, eco-systemic programme of work and agro-sociological collaborative study on rainfed farming. Some of these investigations were taken up solely by SRU as TAC-DCSW approved projects; some others were recently carried out in collaboration with the Agricultural Science Unit, while a few other projects were funded by important external agencies approved by ISI and Government of India. A special initiative has been recently taken to begin the task of computer processing of the huge socio-economic data collected and stored in Giridih since the days of pioneering field surveys of Professor Ramkrishna Mukherjee, involving more than one lakh filled-in questionnaire schedules. This task was recommended by the ISI Council's committee on Giridih branch of SRU which was unanimously accepted by the ISI Council.

Statistical Quality Control and Operations Research Division

The Division continued its activities in the following areas :

1. Development of professionally competent specialists in Quality Control, Reliability and Operations Research (QCR & OR).

2. Imparting inplant appreciation and technical training in QCR & OR for different levels of personnel.

3. Undertaking project studies and service assignments.

4. Promoting the use of quantitative tools and adoption of modern methods of Quality Management.

5. Undertaking theoretical and applied research in the relevant fields.

Special activities pursued by the Division included :

1. Dr. Genichi Taguchi, Father of Quality Engineering visited head quarters at Calcutta, Bangalore and TISCO, Jamshedpur organised 7 seminars covering 701 persons. Two one day symposium on Quality Engineering were conducted; one at Calcutta and another at Bangalore and 160 persons attended.

The message of his talks and seminars were :

Indian industries need Quality Engineering methods much more than developed countries.

Major emphasis for improving product quality at a minimum cost should be for off-line quality control i.e., QA at product & process design stages. Robust technology design would help to promote R & D exercises for designing robust product and process.

2. Providing thrust in helping manufacturing and service organisations to obtain the implementation of ISO 9000 systems. Division has so far helped more than 50 organisations in getting ISO certification and around 10 are in the process.

3. With the active involvement of the Secretary, Department of Statistics, promotional seminars were conducted at NSSO, Delhi, Thackersey Group of Mills at Bombay and Confederation of Indian Industries (CII), Delhi.

4. The secretariat of the Justice, Shri S.C. Talwar Committee sought the assistance of the experts from the Division to study extra departmental system of the posts and telegaphs.

5. Division organised jointly with Stat-Math Unit, Economic Analysis Unit an International Conference on Game Theory and Economic Applications during 2-6, January 1996 at Bangalore.

6. Division conducted a two day TQM programme both at Calcutta and Bangalore to cover more than 60 scientific workers and Quality Mission Executives.

7. Third batch of Quality Mission Executives were recruited. 3 months' inhouse training programme was conducted for them.

8. A mini workshop on Interaction between Computer Science & Mathematics/Statistics was conducted by the Research Cell at Bangalore during 8-9 March, 1996, which brought together the Computer Scientists of I.I.Sc. and Mathematicians/Statisticians of ISI. Experts from different fields spoke on how Computer Science plays an important role in Mathematics and Statistics and vice versa.

9. A Two day Practitioners-Researchers Interface Meet was conducted at Bangalore during March 26-27, 1996 which was attended by 33 scientists from the Division and invitees from Stat-Math Unit. Prof. J.K. Ghosh presided over the meet and more than 18 types of practical problems were presented. The purpose of this meet were

a) Development of methods for tackling practical industrial problems;

b) Improvement in the quality of consultancy services.

The meet recommended approaches/methods to number of practical problems and also suggested the names of different groups to work further development of methods.

10. The first issue of Newsletter of the division was brought out during March 1996 and circulated to around 1200 persons all over India. It is planned to bring out 3 issues per year..

11. Division collaborated with the NIST, Ministry of Commerce, USA for a joint Research Conference on Statistics in Quality, Industry and Technology and papers of seven scientists were accepted for presentation. Two/three are likely to attend the conference.

Projects :

Emphasis on consultancy during the year based on the needs of different industries was mainly in the development of Quality Systems and conduct of inplant and general training programmes. However project applications have been pursued as in the past and about 120 projects were carried out. Salient features of selected Project Studies/Research Project are presented.

1. Improvements of Fuel filters :

The main function of fuel filters is to filter-out the unwanted dirt, unburnt oil, etc., from the engine fuel and thus prevent plugging and restriction of fuel injectors. An orthogonal array application was made and several process and product characteristics were studied. A significant improvement of 2 to 3 folds was achieved in the Dynamic Life keeping the process variation to a minimum.

2. Market Study of ICE CREAM Demand :

As part of this, 380 Retailer outlets, 1100 House holds and 1000 College/School level students were surveyed, besides organising a Consumer preference survey and collecting and analysing past sales data of selectd Retailer Shops. The study helped in funding out the season wise projection of Demand during the ensuing years and the various marketing strategies to be adopted towards it.

3. Elimination of Breakdown of UVC Stripper in a Manufacturing Plant :

Average downtime of the UVC Stripper was estimated to be 8.84 hours per month. Different failure modes were identified and mean time between failures for each failure mode were estimated. Maintenance strategy (including total productive maintenance) was evolved to increase the reliability of the operation of UVC Stripper. On adoption of the strategy average down time of stripper reduced to 0.96 hrs. per month resulting in a saving of Rs.1.98 lakhs per annum.

4. Improving Process of Printed Circuit Board Manufacturing with respect to Opens :

The defect level of PCB's manufactured in a plant was 50,000 ppm due to opening the tracks. The process of PCB manufacture was defined through flow charting. Critical process parameters contributing to opening of tracks at each stage of manufacturing were identified, its performance level studied through appropriate control mechanism. The special cause of variation in the process parameters were arrested through cause effect diagram and other problem diagnostic/solving methodology. Defect level reduced to 2500 ppm resulting in a saving of Rs.6.9 lakhs per anum.

5. Minimisation of Drilling time on PCB's :

Minimisation of the total drilling time on PCB was considered to be a Travelling Salesman Problem in the sense that each node has to be drilled only once and after all the holes are drilled the spindle has to return to the origin which is the starting point. Heuristic approach for the TSP was developed covering three braod classes :

Tour Construction Procedures
Tour Improvement Procedures
Composite Procedures
The pascal programme was developed and implemented. The increase in production was to the extent of 5%.

6. Optimisation of injection moulding process parameters :

In injection moulding process, the process parameters have been standardised through experimentation to bring down the rejection percentage from 60% to 10%. The company has saved Rs.1,50,000/- per month.

7. Optimisation of the resistive printing process parameters :

The resistive printing process have been standardised through fitting and optimisation of response surface and thereby reducing the defect level from 13% to 2%, resulting in an estimated annual savings of Rs.6 lakhs.

8. Improvement upon kriging model for estimation of Alumina and SiO_2 from Bauxite Deposit in a Mine :

Usual kriging does not give satisfactory answers in terms of the kriging variance of the predicted quantities as a result predictability of the output and ultimate mixing get affected. The project aims at subdividing the total region into sub-regions and independently krig for each of the sub-regions by fitting different variograms, through a spherical model with sub-regions not exceeding 500 meters radius.

9. Control of SO_3 gpl in SO_2 :

Using correction method the required sampling interval and correction required on SO_3 gpl is found out. Using regression based on a mathematical model developed using mass balance equations the relationship between SO_3 gpl and control parameters are established and a ready reckoner is prepared so as to get the β correction in a small predetermined interval of time.

10. Hypo Dosage Chart :

A regression model is developed relating hypo C_v with Chlorinated C_v, available Cl_2 in Hypo solution, hypo dosage and from this equation the required hypo dosage is found out depending on Cl_2, C_v, $AvCl_2$ so that hypo C is at target.

11. Control of ClO_2 gpl in ClO_2 water preparation process :

Using regression based on the steady state mass balance equations the relationship with ClO_2 gpl and chilled water flow, $NaClO_3$ flow, $NaClO_3$ gpl are established and a ready reckoner is prepared for the control of ClO_2 gpl.

12. Control of DC% :

Because of the delay in the DC% measurement result from lab, a regression equation is developed to predict the DC% by seeing the other controllable and uncontrollable factors. The condition to be followed so as to get the DC% at target is obtained from this relationship.

13. Control of chlorinated brightness :

A ready reckoner chart is prepared for the adjustments in Cl_2 flow depending on pulp flow, unbleached pulp C_v and previous hour Cl_2 brightness.

14. Robust process design for OPU :

The robust levels for the parameters affecting OPU, viz., pH, circulation rate, Ev, Residue and temp are arrived at by conducting a designed experiment using L_{18} orthogonal array.

15. Control of NaOH % in steep lye :

The required sampling interval and the correction required on an observed NaOH% is found out using β-correction in a small pre-determined interval of time.

16. Study on final fibre properties :

Regression analysis is used to study the effect of Ball fall, acid % return bath difference, cellulose %, etc. on the final fibre properties like spinning fault, bundle tenacity and denier.

The extent of Consultancy, Inplant & General Training Programmes are summarised below :

1. No. of Industrial Units serviced	157
2. General Programmes	
No. of Programmes	20
No. of Participants	402
3. Inplant Programmes	
No. of Programmes	247
No. of Participants	6732
4. Seminars and talks	
No. of Programmes	80
No. of Participants	2878
5. No. of Promotional visits	86

The details of training programme and a list of important factories served under consultancy programme are given in appendix A and B.

Quality Mission Project 1992-97 during 1995-96.

1. Present strength of Quality Mission Executives is as follows :

I Batch	... 5
II Batch	... 7
III Batch	... 8
Total	20

2. The third batch of QME was recruited in October 1995

Three months' orientation programme on ISO 9000 Quality Systems for the III batch was started in October 1995 and was completed in December 1995. 18 faculty members from different units of SQC & OR Division have handled various topics during the programme. The programme has established itself as a complete module of ISO 9000 Quality Systems with the coverage of supplemental requirements to be fulfilled for addressing the clauses of ISO 9000 Quality Systems. The programme received appreciations from internationally well-known consultants and with suitable modifications could be offered as a standard

programme on Quality Management Systems for supervisory and executive staff from industries and service organisations.

3. Existing QMEs of 1st and 2nd batch continued to carry out training, consultancy and promotional activities.

4. A Memorandum of Understanding (MOU) was signed with Central Leather Research Institute (CLRI) for helping leather good industries in ISO 9000 certification. Services have commenced in some units. CLRI expressed its desire to seek such assistance for remaining units.

5. The services of QMEs were also sought by Small Industries Development Bank of India (SIDBI) to provide consultancy & training for implementation of ISO 9000 Quality System to a large number of small units under its aegis.

6. Three out of four core group members are QMEs for providing training and consultancy for Quality Improvement assignment of more than 60 suppliers of Kelvinator plant of Whirlpool (India).

7. Summary of work during the year

11 general training programmes of 2 to 3 days duration have been conducted during the current year involving 30 training days with a total number of participants being 267 drawn from various industries. These programmes were conducted at Indore, Kolhapur, Cochin, Ranipet, Madras and Faridabad.

55 inplant appreciation training programmes of varying durations have been conducted for a total number of participants of 1843. The training programmes covered participants right from senior management down to the shopfloor level employees and in the regional languages such as Tamil, Kannada, Bengali, Telugu and Hindi.

832 mandays of consultancy services were offered by QMEs. Types of industries visited by QMEs for consultancy services, among others, include textiles (Yarn, Fabric and Garments), gem and jewellery, engineering, foundry, chemical, auto ancillaries, plastics and leather.

49 days of promotional visits were taken up by QMEs during the current year. A few such promotional visits have resulted in enlisting the organisations for services of ISI.

Lectures and seminars were conducted by QMEs in institutions like Federation of Indian Export Organisation, Tea Board, Small Scale Service Institute, etc.

8 QMEs have been nominated for Lead Assessor Certification Programme and all of them have successfuly completed the programme.

8. In addition to these training and consultancy activities, papers submitted by QMEs have been accepted at the International Conferences, details of which are as follows :

1. TQM-Prelude, Co-authored by C.Y. Krishnamurti and V.I.G. Menon.

2. TQM-Big Picture, Co-authored by C.Y. Krishnamurti and V.I.G. Menon.

The above papers with a focal theme on TQM in administration and business have been accepted and were presented at World Quality Congress during the month of February 1996 at Delhi. As a sequel, there was proposal to collaborate with ISI in piloting such projects on model scale.

3. A paper on Quality Information Systems by S. Majumdar has been accepted for presentation at International Conference on Quality Control to be held in October 1996 at Tokyo.

Research activities

In recent years the Division has been giving more and more attention to basic and applied research in the areas of statistical method of Quality Control, Operations Research and Reliability in addition to its consultancy and training programme.

The specific areas are Continuous Sampling Plan, Three decision Bayesian Acceptance Sampling plan, Gauge control charts, Bayesian approach to Narrow limit gauging Inspection error, Optimum sampling plans in case of defect interferences, Two dimensional linear knapsack problems, Fuzzy goal programming, Vertical linear complementarity theory and weighted Konig Egervary theorem, Heuristics in inventory study, Construction of repeated measurement designs, Study on effect of welding parameters on weld metal chemistry, Estimating change points in a buth tub failure rate curve.

During the year 10 papers were published in journals, 20 papers were accepted and 10 papers were sent for publication in journals, 15 papers were presented and published in conference proceedings. Two staff members received Ph.D. degree, two thesis were submitted and two scholars are working for the Ph.d. degree.

Appendix A

In-plant training programmes conducted by the SQC and OR Division during April 1995 - March 1996

Sl. No.	Topic	Duration (days)	No. of programmes
1.	Basic Statistics	2-3	4
2.	Simple Tools QC	1-2	3
3.	New 7 QC tools	2	1
4.	SQC for ISO 9000	1-3	20
5.	SQC	3-5	8
6.	SPC	3-5	59
7.	Statistical application in Design and Development	1-3	2
8.	Sampling techniques and acceptance sampling plans	1-3	10
9.	Design of Experiments	1-4	4
10.	Taguchi Methods	1	1
11.	FMEA	1-2	8
12.	Introduction to Operations Research	2	1
13.	Reliability	2-4	3
14.	Defects Prevention and Problem solving	2-13	16
15.	Quality function Deployment	1-2	4
16.	Total Quality Management	1-4	26
17.	Supplier Quality Assurance	1-3	3
18.	ISO 9000 Awareness	1-2	10
19.	ISO 9000 Documentation	2-3	5
20.	Internal Quality Audit	3-8	17
21.	Quality Engineering	3	1
22.	Operators Training Programme QC	1-3	20
23.	Advanced Statistical tools	3	1
24.	Top Management appreciation programme on SQC	1-2	16
25.	Test of Significance	4	3
26.	Team Oriented Method	10	9

Appendix B

List of important Factories served by SQC & OR Division

HMT Ltd. (11 units) ; INDAL (3 units) ; Stumpp, Schuele and Somappa Ltd., Bangalore ; Electronics Research Laboratory Ltd., Bangalore ; Kirloskar Brothers Ltd. (2 units) ; Grasim Industries Ltd. (3 units) ; Glowtronics Ltd., Mysore ; Auma India Ltd., Bangalore ; Kirloskar Copeland Ltd., Karad ; Peninsula Polymers (P) Ltd., Trivandrum ; Balmer Lawrie and Co. Ltd. (3 units) ; Cuffast Abrasives Tools Ltd., Madras ; TANFAC Industries Ltd., Cuddalore ; Salem Textiles Ltd., Salem ; Florind Shoes Ltd., Ambur ; Jayashree Textiles Ltd., Calcutta ; Exide Industries Ltd., Haldia ; Birla Cements Ltd., Durgapur ; ICI (3 units) ; A Sirkar (Jewellers) Pvt. Ltd., Calcutta ; Andrew Yule (3 units) ; Orissa Cements Ltd.; Indian Oil Blending Ltd. (4 units) ; Wipro, Consumer Products, Amalner ; Jain Plastics and Chemicals Division (Papain Product Group), Jalgaon ; Sundaram Fasteners Ltd (3 units) ; Visalakshi textiles Ltd., Madurai ; Hical Magnetics Ltd., Bangalore ; Rao Insulating Company Ltd., Bangalore ; Murudeshwar Ceramics Ltd., Hubli ; Modi Xerox Ltd., Modinagar ; Widia (India) Ltd., Bangalore ; Motorola (India) Ltd., Bangalore ; Hewlett Packard Ltd., Bangalore ; Wipro Peripherals Ltd., Mysore ; Larsen and Toubro Ltd., Bangalore ; TAFE Ltd., Doddaballapur ; Aerospace Division. HAL. Bangalore ; RHW Autoliv India Ltd., Bangalore ; TITAN Industries, Hosur ; BEML K G F; Kinetic Engineering Ltd., Ahmednagar ; General Optics Ltd., Pondicherry ; Rajapalayam Mills, Rajapalayam ; Lakshmi Saraswathi Textiles, Arni ; Gnanambika Mills Ltd., Coimbatore ; Thambi Modern Spinning Mills, Salem ; Sudarsanam Spinning Mills, Rajapalayam ; Sri Vishnu Shankar Milla, Rajapalayam ; Sree Narayana Krishna Spinners Ltd., Udumalpet , SLS Textiles, Andhra Pradesh ; Sambandham Spinning Mills, Salem ; Sree Akkamamba Textiles Ltd., Tanuku, Andhra Pradesh ; Kandagiri Spinning Mills Ltd., Salem ; Palani Andavar Cotton and Synthetic Spinners Ltd., Udumalpet ; Gujarat Communications and Electronics Ltd., Baroda ; Patwa Kinariwala Electronics Ltd., Baroda ; L K Pace India Private Ltd., Baroda ; Gujarat State Fertilizer Company Ltd., Baroda ; United Catalysts (I) Ltd., Baroda ; BHEL ; Kalpataru Power Transmissions Ltd., Gandhinagar ; Atlas Dye-Chem Industries ; ATE Enterprises Ltd., Ahmedabad ; DGP indsor India Ltd., Ahmedabad ; Antifriction Bearings Corporation Ltd., Bharuch ; Gujarat Propack Ltd., Ahmedabad ; New Shorrock Mills Ltd., Nadiad ; Crompton greaves Ltd., SPC Division, Nasik ; Sudarshan Chemical Industries Ltd., Pune ; Fleet guard Filtration Systems (India) Pvt. Ltd., Pune ; The Kolhapur Steel Limited, Kolhapur ; Precimax Bearings Pvt. Ltd., Kolhapur ; Mahindra and Mahindra Ltd., Bombay ; KSB Pumps Ltd., Pune ; Spentex Industries Ltd., Baramati ; Technova Imaging Systems Ltd., Taloja ; Bharat Electronics Ltd., Taloja ; Standard Batteries Ltd., Bombay ; Bumper (India) Ltd., Bombay ; Gratex Ltd., Bombay ; Godrej and Boyce Mfg. Co. Ltd., Bombay ; Bharat Petroleum Corporation Ltd., Bombay ; Sn Nataraj Ceramics and Chemical Industries Ltd., Dalmiapuram ; T Abdul Wahid and Co., Ambur ; Antrieb Technik Private Ltd., Madras ; Engine Valves Ltd., (2 units) ; Engine Valves Ltd. ; Whirlpool India Ltd. (2 units) ; Tractors and Farm Equipments Ltd., Madras ; Mathia's packaging Industries Ltd., Madras ; Arvind Mills Ltd., Ahmedabad ; N.F. Private Ltd., Madras ; Farida Shoes Private Ltd., Madras ; Ordance Factories (4 units) ; Gramophone Company of India Ltd., Calcutta ; Hyderabad Industries Ltd. ; Hindustan Motors Ltd; DCM Ltd., Delhi ; IED Ltd ; Gapp Industries ; Opto Electronics ; Ferro Alloys Corporation Ltd., Garivedi ; Nagarjuna Stells Ltd., Patancheru ; SRMT, Kakinada ; Bharat Dynamic Ltd., Bhanur ; Nava Bharat Ferro Alloys Ltd., Paloncha ; Sulakshana Circuits Ltd., Hyderabad ; National Ship Research Development Centre, Vishakapatnam ; SAMKRG Pistons Ltd., Hyderabad ; Naravita Agro Products Ltd., Hyderabad ; Priyadarshini Spinning Ltd., Hyderabad ; Western India Plywoods Ltd., Kanpur ; Tata Tea Ltd., Munnar ; Thiruvananthapuram Regional Co.op Milk Products, Union, Trivandrum ; Peninsula Polymers Ltd., Trivandrum ; United Catalysts (India) Ltd., Ernakulam ; L and T. Engineering Project and Equipment Group, Calcutta ; ITC (Triveni Tissue Division), Calcutta ; Peerless Hospital, Calcutta ; Metflow Industries Ltd., Calcutta ; Birla Jute and Industries Ltd., Calcutta ; Exide Industrial (Haldia Unit) ; JCT Ltd., Hosiarpur ; Samtel India (2 units) ; Teletube Electronics ; Gujrat Refinery.

The activities of DRTC have been organised into several programmes, such as (a) Research Programme; (b) Avisory service programme; (c)(i) Extension programme, (ii) Publication programme, (d) Educational and Training programme; (e) Employment information programme; (f) Continuing educational and training programme; and (g) Faculty development programme.

1. Training in Documentation and Information Science

Course leading to "ADIS" Award :

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

The academic session, 1995-1997 (24 months) commenced on 1st September 1995. There were nine students selected for this session.

2. Short term course on Computerised Information Work and Service

Under the sponsorship of the National Information System for Science and Technology (NISSAT) of the Department of Scientific 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. However, in the last two years, only one course is being conducted per year. The 17th course was conducted in the month of January 1995.

3. Research activities

The main areas of research in which the different members of the DRTC Faculty were engated during the period, April 1995 to March 1996 are furnished below : (1) The application of the "Colon Classification, ED.7" for the purpose of (a) arranging documents; and for (b) documentation work and service; (2) The study of various method of knowledge representation, such as, semantic nets, frames, and predicate calculus, etc.; (3) The application of the "Modern scientific management techniques" to the planning and management of information systems, centres and services; (4) The study of the methodologies of information analysis and consolidation; (5) The development of bibliometric measures for evaluating the use of library and information services; (6) The preparation of guidelines and actual development of software and application packages for library house keeping operations, such as, circulation control service control and acquisition control; (7) Development of Software for OCR and for Multimedia applications.

Externally funded Project Work .

1. One of the externally funded projects of DRTC, 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. Report of this project has already been furnished in Section 2.2.

2. This is a second ongoing NISSAT sponsored project at DRTC. It is on the Application of Optical Character Recognition Technology in building Bibliographic DBMS. It began in July 1995. Various character recogniser features of Print-on-paper of various image qualities.

Bangalore

1. Additions to the library during April 1995 to March 1996

Book Acquisition : During the above period 430 books were added to the library by purchase, 21 books were received on gatis.

Stock position : The total stock position as on 31st March 1996 is as follows :

Books - 14047, Books on gratis - 936, Bound volumes of Periodicals - 6576, No. of Periodical titles subscribed - 240, No. of Periodical received on gratis - 18.

2. Technial Processing

About 350 books were classified and catalogued during the year. Nearly 1750 catalogue cards were filled.

3. Circulation Statistics

During the year library facilities were enjoyed by 211 users. 140 of them availed the lending facilities. 4 visiting Professors of different Units of ISI were also provided with the lending facilities. A total of about 12240 books and periodicals (including loose issues) were circulated by the library. The in house use of books and periodicals were around 29000. About 110 inter library loan transactions were registered.

The membership includes ISI staff, Research scholars, project assistance, M.Stat. students, M.Tech Students, SDP fellows, DRTC students, Trainees of DRTC short term computer courses etc.

4. Inter Library loan service

Inter library loan facilities were availed by (the Indian Statistical Institute) Bangalore Centre Library users from the following local libraries.

British Library, Bangalore
Indian Institute of Management, Bangalore
Indian Institute of Science
Tata Institute of Fundamental Research, Bangalore

4.1 Indian Statistical Institute, Bangalore Centre Library extends inter library loan facility to:
Indian Institute of Science
Tata Institute of Fundamental Research, Bangalore

5. Reprographic Service

Library provided 1,52,000 xerox copies to the users during the period April 1995 to 1996.

6. Documentation Service

The following publications were brought out regularly from the library.

Bimonthly additions list of books
Monthly list of current periodicals
Current contents of journals.

Calcutta

With the addition of 1179 books and 4293 bound journals to the stock, the total collection of the Library rose to 2,03,914.

1. Acquisition Unit

The unit accessioned 1179 books during the period under report, out of which 1090 were purchased and 89 were received as gift.

2. Periodicals Unit

The unit received 812 periodicals out of which 160 were received as gift, 452 against sugscription and 200 on exchange arrangement with national and international organisations. The unit acquired 14 new journals. 26 journals were subscribed under NBHM grant. It accessioned 4293 journals and completed the technical processing of 5143 journals.

3. Circulation & Stock Maintenance Unit

The unit issued 60928 books and journals to the users on loan and reference. The total membership of the Library was 1717 and 1100 memberships were withdrawn. The total membership includes ISI staff, Research Scholars, Project Assistants, B.Stat. and M.Stat. students, ISEC Trainees etc. as well as outside students and institute members. 716 readers were given special permission to use the library for a short period. 112 books and journals were borrowed from other libraries and 65 books and journals were loaned to the other libraries under the inter-library loan arrangement.

4. Reports & Records Unit

The unit accessioned 184 titles and processed 432 titles. 880 titles were issued to borrowers for reference use during the period.

5. Circulating Library

The Workers' Circulating Library acquired 391 new titles bringing the total collection to 36029. It issued 22621 books to the members.

6. Technical Processing Unit

The unit classified 1154 books and catalogued 1420 books.

7. Documentation Unit

The unit has been regularly issuing (i) monthly current contents of journals in the following groups of subjects: Statistics, Mathematics, Statistical Quality Control, Electronics and Communication Sciences, Geology, Life Sciences and Economics; and (ii) monthly additions list of books to the Library. The Unit completed the compilation work on Catalogue of Russian Collections in the Library, a selection of reading list on geology, a bibliography on quality of working life and reading list on new economic policy and structural adjustments in the agricultural sectors in India (ongoing).

8. Reprography & Photography Unit

The unit provided 7,07,316 xerox prints for the users during the period under report.

980 frames of photographs of different natures, 3947 prints of photographic enlargements, 151 frames of lecture slides were made during the period under report. 3,39,350 pages of off-set prints were done during the period under report.

Delhi

1. Acquisitions

Due to budget constraints, only 278 new books could be purchased and added to the stock. The library received 51 publications as gift from various sources. 400 sets of loose issues of periodicals duly bound had been added to the stock, thus raising the stock to 32810 volumes. About 200 Technical reports/Discussion papers/Reprints etc. in Economics have been received during the above period.

2. Periodicals

228 titles of journals, both foreign as well as Indian have been approved for renewal for the year 1995-96. In addition 28 titles of journals were received as complimentary and against exchange programme. 400 sets of loose issues of journals duly bound were added to the stock. Five new titles have been subscribed from the year 1996. Journals/Technical Reports have been received under the exchange programme established with different institutions for exchange of journal Sankhya and publications published under the series "Texts and Reading in Mathematics".

3. Circulation

During the period April 1, 1995 to March 31, 1996, 126 members availed the lending facilities as permanent members, and 56 members availed the reference facilities as temporary members. Approximately 6200 publications were circulated during the period among its members. Under the inter library loan program, about 17 publications were lent out to the neighbouring institutes and libraries and 12 publications were borrowed from them for use by Delhi Centre Library members.

4. Reprographic service

Approximately 23000 photocopies were made during the period on the request of users of library. Reprographic facilities have also been provided to researchers of other institutes on a nominal payment of Rs.0.50 p. per page.

5. Other activities

National Board of Higher Mathematics, Department of Atomic Energy, Govt. of India has recognised Indian Statistical Institute, Delhi Centre Library as the Regional Library to serve the Northern Region w.e.f. 1.4.1994 and the annual grant of Rupees 6.00 lakhs has been renewed.

Out of N.B.H.M. Grant a total about 53 new books have been purchased and the back volumes of three journals were ordered for procurement.

Apart from back volumes of journals, four new journals have been subscribed from N.B.H.M. Grants.

Like every year this year too Library Trainees with remuneration had been appointed. At the end of their training, each trainee was given an experience certificate.

Computer and Statistical Services Centre

The Computer & Statistical Service 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 SPARCASTATION I. NSSO and CSO (I-S Wing), Govt. of India are using these facilities as well. E-mail and FAX facilities of the Institute are also maintained by the centre.

This year CSSC has purchased two PCs, one of which would be used as the server of a PC-Net to be built next year. The centre has also purchased Window-95 and Visual Basic compiler for providing training to the students. The Institute has decided to instal a VSAT terminal to extend complete INTERNET facility to its scientific workers. For this purpose, order has already been placed.

Like all other years, the staff members of CSSC have served as faculty in various courses of the Institute and supervised dissertation carried out by the students. The staff members of CSSC are also involved in research covering the areas like database and knowledge bases, image processing, computational geometry, VLSI design etc. The detail of the different activities of the centre are enclosed.

4. EXTERNALLY FUNDED PROJECTS

A. Ongoing Projects :

1. Name of the Project : Automatic feature extraction from satellite images and image data Compression.
   Name of the Project Leader : B.B. Chaudhuri.
   Unit involved : Computer Vision and Pattern Recognition.
   Funded by : Advanced Data Analysis Research Institute, Hyderabad.

2. Name of the Project : Studies on the PBL dynamics using SODAR and tower data and to predict a scalar transport model for the monsoon period.
   Name of the Project Leaders : J. Das and A.K. De.
   Unit involved : Electronics and Communication Sciences.
   Funded by : Dept. of Science and Technology, New Delhi.

3. Name of the Project : Deformation, metamorphism, anatexis and magmatism across the northern boundary of the Eastern Ghats mobile belt around Rangall, Orissa.
   Name of the Project Leader : S. Bhattacharya.
   Unit involved : Geological Studies.
   Funded by : Dept. of Science and Technology, New Delhi.

4. Name of the Project : A neuro-fuzzy image recognition system : Methodology development for forensic applications.
   Chief Investigator : S.K. Pal.
   Unit involved : Machine Intelligence (in collaboration with State Forensic Lab., Belgachia).
   Funded by : CSIR, New Delhi.

5. Name of the Project : A study of mathematical techniques in water wave problems.
   Name of the Project Leader : B.N. Mandal.
   Unit involved : Physics and Applied Mathematics.
   Funded by : CSIR, New Delhi.

6. Name of the Project : Unsteady, surface water waves in ocean.
   Name of the Project Leader : B.N. Mandal.
   Unit involved : Physics and Applied Mathematics.
   Funded by : University Grants Commission, New Delhi.

7. Name of the Project : Genetic of quantitative traits of commercial importance in the silkworm.
   Project Coordinator : P.P. Majumder.
   Unit involved : Anthropometry and Human Genetics.
   Funded by : Central Silk Board/Department of Biotechnology, Govt. of India.

8. Name of the Project : Evaluation of 'Rainfed Farming Project' (RFP).
   Name of the Project Coordinator : Atis Dasgupta.
   Units involved : Sociological Research and Agricultural Sciences.
   Funded by : Hindustan Fertiliser Corporation Ltd. (HFCL).
   Sponsored by : Overseas Development Authority (ODA), U.K.

9. Name of the Project : Evaluation of Total Literacy Campaign (TLC) in Calcutta Metropolitan District.
Name of the Project Coordinator : Atis Dasgupta.
Unit involved : Sociological Research and Population Studies.
Funded by : Calcutta Municipal Corporation.

10. Name of the Project : Guidance and Consultancy Services in Data Processing.
Name of the Project Coordinator : Prafulla Chakrabarti.
Unit involved : Sociological Research.
Funded by : Indian Council of Social Science Research, New Delhi.

11. Name of the Project : An enquiry into the quality of life of five communities in West Bengal.
Principal Investigators : Kumar Chattopadhyay, Atis Dasgupta, Prafulla Chakraborty, S. Guha Roy.
Unit involved : Population Studies, Economic Research and Sociological Research.
Funded by : West Bengal Commission for other Backward Classes.

12. Name of the Project : Survey of the possibilities and problems of small industries in Birbhum district.
Project Leader : Atis Dasgupta.
Units involved : Sociological Research, Economic Research, Computer Science..
Funded by : West Bengal Small Industries Corporation, Govt. of West Bengal.

13. Name of the Project : In-depth studies on the levels of development of SCs and STs.
Project Leader : Atis Dasgupta.
Units involved : Sociological Research, Stat-Math, Population Studies.
Funded by : Ministry of Welfare, Govt. of India.

14. Name of the Project : Gender study for district primary education programme.
Project Leader : Anjali Ghosh.
Unit involved : Psychometry Research and Service and Sociological Research.
Funded by : Govt. of West Bengal.

15. Name of the Project : Livelihood strategies and knowledge systems under environmental stress.
Project Coordinator : D.K. Bagchi.
Unit involved : Agricultural Sciences.
Funded by : University of East Anglia, Norwich, U.K.

16. Name of the Project : Development of statistical techniques as an aid to geological mapping.
Project Leaders : J.K. Ghosh and Tapas Samanta.
Units involved : Stat-Math, Computer Science.
Funded by : CSIR.

17. Name of the Project : Tracer study of ITI certificate holders.
Project Leader : A.C. Mukhopadhyay.
Unit involved : Computer Science.
Funded by : Central Staff Training Research Institute, Govt. of India.

18. Name of the Project : Large amplitude ion and electron acoustic solitary waves in a relativistic plasma.
Project Leader : R.K. Roychoudhury.
Unit involved : Physics and Applied Mathematics.
Funded by : DST.

19. Name of the Project : Development of thin film on a rotating disk.
Project Leader : B.S. Dandapat.
Unit involved : Physics and Applied Mathematics.
Funde by : CSIR.

20. Name of the Project : Regression methodology statistics.
Project Leader : D. Sengupta.
Univ involved : Computer Science.
Funded by : DST.

21. Name of the Project : Migration and genetic differences among Maria Gonds.
Project Leader : Ketaki Das.
Unit involved : Anthropometry and Human Genetics.
Funded by : DST.

22. Name of the Propject : Molecular epistasis and human globin gene clusters with special reference to haemoglobinopathies in eastern India.
Project Leader : Partha P. Majumder.
Unit involved : Anthropometry and Human Genetics.
Funded by : Dept. of Biotechnology, Govt of India.

23. Name of the Project : Computerised archaeological information base.
Project Leader : A. Bagchi.
Unit involved : Computer and Statistical Services Centre.
Funded by : Govt. of West Bengal.

24. Name of the Project : Development of a knowledge-based computing system for analysis of various biomedical images (CT, MRI, SPECT, etc.).
Project Leaders : D. Dutta Majumder and J. Das.
Unit involved : Electronics and Communication Sciences.
Funded by : CSIR.

25. Name of the Project : Development of computer algorithm for recognition and interpretation of Sodar patterns.
Name of the Chief Investigators : J. Das and A.K. De.
Unit involved : Electronics and Communication Sciences.
Funded by : Dept. of Science and Technology, New Delhi.

26. Name of the Project : ISI-PCL manpower development projects.
Project Co-ordinator : B.B. Chaudhuri
Unit involved : Computer Vision and Pattern Recognition
Funded by : Pertech Computers Limited, Calcutta.

B. Completed Project :

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.

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

The Symposia, Conferences Workshops, Lectures and Seminars organised by the Institute during the year 1995-96 are listed below :

Symposia, Conferences, Workshops

A workshop on "Microbial Degradation of Municipal Solid Waste" was organised jointly with the Nodal Research Centre, Calcutta. The Workshop was held in the Institute at Calcutta on 4 May 1995.

A Summer School on Descriptive Set Theory and Applications was organised by Stat-Math Unit, Calcutta, during 29 May 1995 to 17 June 1995.

A Winter School on "Group representations and Function Theory" was held at the Jawaharlal Nehru Centre, Bangalore, from October 2 - 14, 1995 by the Stat-Math Unit, Bangalore.

The NBHM Nurture programme was conducted at the Bangalore Centre in June 1995.

An International Conference on "70 years of Quantum Mechanics and Recent Trends in Theoretical Physics" was organised by the Physics and Applied Mathematics Unit in Calcutta during 29 January - 2 February, 1996.

A Summer School on "Advanced Econometric Techniques and Their Applications" was organised by the Economic Research Unit, Calcutta from June 19 to July 7, 1995.

A Workshop on "Image Processing Techniques" was organised by Computer Vision and Pattern Recognition Unit, Calcutta during June 26 - July 1, 1995.

The 32nd Annual Conference of the Indian Econometric Society was organised by the Economic Analysis Unit, Bangalore, during 21-23 March, 1996.

A three-day workshop on Libraries and Information Centres as Profit-Making Institutions was sponsored by the DRTC (ISI) and NISSAT (Govt. of India), New Delhi. It was held at the Institute of Information Studies, Bangalore, from 9 to 11 August, 1995.

Prof. A. Neelameghan, Hon. Visiting Professor, DRTC delivered the second series of "Ranganathan Birth Centenary Lectures" during 9-11 August 1995 at the Institute of Information Studies, Bangalore. He spoke on "User Interface and Information Systems". The programme was conducted by the Sarada Ranganathan Endowment for Library Science, Bangalore, in collaboration with DRTC.

Dr. G. Bhattacharya delivered a lecture on "Ranganathan's Contribution to Library and Information Science" in a programme organised by the DRTC, Institute of Information Studies and Sarada Ranganathan Endowments on 12th August, 1995 at the Institute of Information Studies, Bangalore-10.

DRTC and DRTC Alumni Association, Institute of Information Studies, Jointly organised the Five Laws Lecture to commemorate the death anniversary of Dr. S.R. Ranganathan. Sri K.S. Naganarasimha, Senior Scientist, C.M.T.I., Bangalore delivered the lecture on Metal Costing databases at NICMAP on 27th September, 1995.

CVPR Unit organised a workshop during 26 June - 1 July, 1995 on Image Processing techniques.

Lectures/Seminars organised by the Institute and delivered by visiting scientists are listed below :

Theoretical Statistics and Mathematics Division

Calcutta Unit

Adak, Sudeshna, Stanford University, USA (24.7.1995) : Time-Dependent Spectral Analysis of Nonstationar Time Series.

Adke, S.R., University of Poona (14.2.1996) : Standard Processes.

Athreya, K.B., Iowa State University, USA (2.4.1996) : Branching Markov Chains.

Athreya, K.B., Iowa State University, USA (2.4.1996) : Theoretical Issues on Markov Chain Monte Carlo.

Bhattacharjee, M.C., New Jersey Institute of Technology and Bell Laboratory, AT & T, USA (9.11.1995) Sharp Stochastic Comparison and Bounds for a Class of Shock Models.

Bose, Smarajit, Ohio State University, USA (10.7.1995) : Flexible Discrimininant Analysis.

Burma, D.P., Centre for Molecular Biology and Genetic Engineering, Benaras Hindu University (6.12.1995) Molecular Basis of Evolution of DNA and Dinucleotide Frequency Map (DNFM).

Burman, Prabir, University of California, USA (7.8.1995) : Model Fitting via Testing.

Chaturvedi, Ajit, CCS University, Meerut (4.9.1995) : On the classes of Two-Stage Estimation Procedures.

Dani, S.G., TIFR, Bombay (18.10.1995) : Concentratation functions of probability measures on matrix groups

Das, Shubhabrata, University of Nebraska, USA (17.7.1995) : Restriction of weights in canonical correlatio and principal component analysis.

Dutta, Amartya Kumar, T.I.F.R., Bombay (11.12.1995) : A^1 - bundles of affine morphisms.

Hampel, Frank, Swiss Federal Institute of Technology, Switzerland (12.10.1995) : Successful bets and th fiducial argument.

Hampel, Frank, Swiss Federal Institute of Technology, Switzerland (13.10.1995) : Enforced fair bets Continuous surprises and other paradigms.

Huda, S., King Saud University, Saudi Arabia (25.8.1995) : Optimal Third-Order Symmetric Product Design For Cubic Regions.

Iyer, Srikant, Technion, Israel (14.9.1995) : Polymer Measure For Brownian Motion.

Jackiw, R., M.I.T., USA (1.2.1996) : My encounters – as a Physicist – with Mathematics.

Kundu, Subrata, University of California, USA (21.8.1995) : Sequential Density Estimation.

Matis, James H., Texas A & M University, USA (30.10.1995) : Describing Biological Spread Using Birth & Death Migration Models.

Mukherjee, Gautam, SPIC Science Foundation, Madras (3.4.1996) : Equivariant cobordism.

Mukhopadhyay, Saurabh, University of Connecticut, USA (3.8.1995) : Dirichlet Process Mixed Generalized Linear Models.

Nelson, James E., University of Colorado, USA (17.8.1995) : Statistical Analysis Procedures Used In Marketing Research in the U.S.

Oja, Hannu, University of Oulu, Finland (30.11.1995) : Multivariate sign and rank tests (and related estimates).

Oja, Hannu, University of Oulu, Finland (4.12.1995) : Multivariate medians.

Oja, Hannu, University of Oulu, Finland (5.12.1995) : Affine invariant multivariate sign and rank tests.

Pal, Nabendu, University of Southwestern Louisiana, USA (21.12.1995) : Decision theoretic estimation of a Normal variance : A critical review.

Pattanayak, S., Sambalpur University (6.11.1995) : Random Fourier Series, Stochastic Integrals and Fractals.

Sen, Pranab Kumar, University of North Carolina, USA (18.12.1995) : Statistical Functionals, Hadamard Differentiability and Martingales.

Sridharan, R., T.I.F.R., Bombay (13.2.1996) : Discriminance of involutions.

Unni, K.R., Formerly of Institute of Mathematical Sciences, Madras (15.9.1995) : On Wavelets.

Viswanath, K., University of Hyderabad (10.10.1995) : Sensitivity on Dynamical Systems.

Viswanath, K., University of Hyderabad (11.10.1995) : Iterated Function Systems and Applications.

Yanai, Haruo, National Centre for University, Tokyo, Japan (13.12.1995) : Projection operator in terms of Kronecker product of matrices and its application to estimation of parameters in multivariate linear model with some restrictions.

Bangalore Unit

Athreya, K.B., Iowa State University : Law of Large Numbers for Branching Markov Processes.

Bhat, Rajaram, Fields Institute, Canada : A recent classification of purely infinite C^* Algebras.

Chaudhuri, Probal, Indian Statistical Institute, Calcutta : Geometry of Data Clouds and Multivariate Inference.

Douglas, R.G., SUNY, Stony Brook : Operator theory and algebraic geometry.

Folland, G.B., University of Washington : Applications of *sl(2)* in Analysis.

Gubbi, Ananda V., University of Pittsburgh : A multivariate statistical procedure for small size data with large number of variables.

Jeganathan, P., University of Michigan, U.S.A. : On Asymptotic Inference in Cointegrated Time Series with Fractionally Differenced Errors.

Kerman, R., Brock University : Weighted norm inequalities for certain classical operators in Fourier Analysis.

Koranyi, A., CUNY, New York : Hilbert spaces of holomorphic functions on bounded symmetric domains.

Krishna, J.V., The Washington State University, U.S.A. : Iterated sums of regression residuals and tests for change - points.

Sethuraman, J., Florida State University : Practical Bayesian Analysis and the Theoretical Questions it Raises - Gibbs sampling, MCMC and Importance Sampling.

Sethuraman, Sunder, ETH, Zurich : Fluctuations for Interacting Particle systems with Exclusion.

Shukla, R.P., Mehta Research Institute, Allahabad : Representations of Chevalley Groups in the Natural Characteristic.

Sinha, K.B., Indian Statistical Institute, New Delhi : Dynamical Semi Groups.

Srinivas, V., TIFR, Bombay : Rotman's theorem for singular vericties.

Varadarajan, K., University of Calgary, Canada : Isometric Shift Operators on $C(X)$.

Venkatalakshmi, G. Universite de Positiers : A Version of Paley-Wiener theorem for nilpotent Lie groups.

Vidyasagar, M., Centre for Artificial Intelligence and Robotics, Bangalore : The Mathematics of Control Theory.

Applied Statistics, Surveys and Computing Division

Computer Science Unit

Banerjee, Anurag, Center of Economic Research, Katholike University, Nederlands (18.1.1996) : Sensitivity of Least Square Estimates.

Das, Shubhabrata, University of Nebraska at Lincoln (18.7.1995) : Asymptotic Distribution and Relevant Resampling Methods for Restricted Canonical Correlations (RCC).

Das, Kalyan, Calcutta University (26.3.1996) : Salamander Mating Experiment-Revisited.

Ghosh, Joydeep, University of Texas, Austin (4.1.1996) : Links between Neural Networks and Statistical Pattern.

Lahiri, P., University of Nebraska-Lincoln, USA (13.2.96 and 20.2.96) : Small-area estimation with an application.

Pattanayak, Swadhin, Sambalpur University (14.11.95, 16.11.95 and 17.11.95) : Fractals and some of their applications.

Sahoo, Prasanna, University of Louisville, USA (28.11.1995) : Image Compression Using Fractal Interpolation Functions.

Sarkar, Abhinanda, Stanford University (25.7.1995) : Model-free regression diagnostics via randomization.

Sinha, Debajyoti, University of New Hampshire (20.6.1995) : Analysis of Interval-censored Survival Data Using Posterior Likelihood.

Physical and Earth Sciences Division

Electronics Unit

Das, Sajal Kumar, Associate Professor, Dept. of Computer Science, University of North Texas, USA (9.1.96 and 11.1.96) : Conflict-Free Data Structure Access in Parallel Memory Systems.

Das, Sajal Kumar, Associate Professor, Dept. of Computer Science, University of North Texas, USA (16.1.96 and 18.1.96) : Mobile Computing.

Das, Sajal Kumar, Associate Professor, Dept. of Computer Science, University of North Texas, USA (30.1.1996) : Performance of Shared-Memory Multiprocessors in the Presence of Hot Spots.

Min, Yinghua, Academia of Sinica, Beijing (30.11.1995) : Boolean Process and its Application to VLSI.

Yuba, Toshitsugu, Dept. of Information and Network Science, University of Electro-Communications, Tokyo (4.9.95 and 6.9.95) : New Generation Computer Development Towards the 21st Century.

Geological Studies Unit

Chatterjee, Sankar, Texas Tech. University, USA (17.5.1995) : Dinosaur extinction : The tale of two craters.

Machine Intelligence Unit

Alagar, V.S., Dept. of Computer Science, Concordia University, Montreal, Canada (24.8.95 and 25.8.95) : Formal Specifications for Software Reuse and Validating System Requirements a Formal Approach.

Basu, A., Owen Graduate School of Management, Vanderbilt University, Nashville, USA (1.3.1996) : Meta Graph : Work-Flow Application.

Dhar, A., Dept. of Theoretical Physics, Tata Institute of Fundamental Research, Bombay (17.8.1995) : Chua's Chaotic Electronic Circuit : A Lecture - Demonstration.

Kothari, R., Assistant Professor and Director, Artificial Neural Systems Laboratory, University of Cincinnati, USA (21.7.1995) : Multi-Valued Neural Associative Memory.

Mitra, S.K., Dept. of Electrical and Computer Engineering, University of California, Santa Barbara, CA, USA (24.12.1995) : Two-Dimensional Teager Operators and Their Image Processing Applications.

Physics and Applied Mathematics Unit

Bhattacharyya, J.K., IIT, Kanpur (26.5.1995) : Protein Folding.

Chakraborty, B., Saha Institute of Nuclear Physics (26.7.1995) : An Introduction to the theory of complex systems.

Chaudhury, K.S., Dept. of Mathematics, Jadavpur University (27.3.1996) : Regulation of a single species fishery by taxation.

Kar, K., Saha Institute of Nuclear Physics (19.7.1995) : Beta Decay Rates in Astrophysics.

Panja, M.M., Visva Bharati (9.8.1995) : Geometric Phase via evolution operator - Invariant technique.

Social Sciences Division

Economic Research Unit

Chakraborty, Achin, A.B.N. Seal College, Cooch Behar, W.B. (22.5.1995) : Assessing improvement in living standard across countries.

Chatterjee, Kalyan, Pennsylvania State University, U.S.A. (11.6.1995) : Multiperson bargaining with strategic complexity.

Fontains, Jean-Mare, Universite Pantheo-Sorbonne, Paris (4.1.1996) : Real wage, rate of exchange and foreign trade reforms.

Hossain, Akhtar, University of Newcastle, Australia (28.11.1995) : Structural change, labour mobility and trade balance in Bangladesh.

Lahiri, Sajal, University of Essex, England (20.4.1995) : Competition for aid and trade policy.

Mallick, Soumitra, Indian Institute of Social Welfare and Business Management, Calcutta (1.2.1996) Incomplete financial markets and non-existence of Arrow-Debreu equilibrium.

Poddar, Sougata, CORE, Belgium (21.9.1995) : Demand fluctuations and capacity utilization under duopoly

Sengupta, Sarbajit, Visva-Bharati, W.B. (14.12.1995) : Control vs. Competition : Multinationals and joint ventures in liberalizing economics.

Sikdar, Soumen, University of Calcutta, Calcutta (14.9.1995) : Choice of organizational form in duopoly.

Economic Analysis Unit

Bala, Venkatesh, Dept. of Economics, McGill University, Montreal, Canada (7.8.1995) : Technological Diffusion Process Over Time and Space : An Application of a Stochastic Diffusion Process.

Sociological Research Unit

Ara, Shawkat, Rajshahi University, Bangladesh (8.3.1996) : Student activism and psycho-social variables : Some glimpses from Bangladesh.

Habib, Irfan, Aligarh Muslim University (6.11.1995) : The history of development of technology in India.

Hinton, William, (28.2.1996) : China, yesterday and today.

Islam, Nazrul, (24.5.1995) : The Hindu-Muslim relationship in Bengal.

Munshi, Surendra, Indian Institute of Management, Calcutta (24.8.1995) : The classical thinkers in sociology

Ray Chaudhuri, Tapan, St. Antony's College, University of Oxford (23.2.1996) : Transformation of religious sensibilities in Bengal in the 19th century.

Sankrityayan, Jeta, North Bengal University (14.11.1995) : Rahul Sankrityayan's intellectual journey from 'Ganga to Volga'.

von Eschen, Donald, McGill University, Montreal, Canada (20.7.1995) : Capitalist penetration and class polarization among the peasants.

Library, Documentation and Information Sciences Division

Browne, Maricad, Dean, University of Technology, Sydney, Australia (16.11.1995) : Library and Information Science Education in Australia.

Heltzman, James, Fulbright Research Professor Institute of Social Economic Change (24.5.1995) : Bangalore Metropolitan Public Library.

Heltzman, James, Fulbright Research Professor Institute of Social Economic Change (25.5.1995) : Geographic Information Systems.

Heltzman, James, Fulbright Research Professor Institute of Social Economic Change (26.5.1995) : Information Society and Bangalore.

Madon, Shirin, Information Systems Dept., London School of Economics and Political Science, London (21.7.1995) : Information Systems for Rural Development Planning.

Matsumoto, Katsuhisa, Reader, Library and Information Sciences Dept., Sakushin Garuin Women's College, Japan (16.11.1995) : Library Education in Japan.

6. PUBLICATIONS

Sankhyā

Founded and edited by Professor P.C. Mahalanobis in 1933 *Sankhyā*, the Indian Journal of Statistics and the official organ of the Indian Statistical Institute is now published bi-monthly in two series - Ser. A on Probability and Mathematical Statistics, and Ser. B on Statistical Methodology and Applications including Sample Surveys and Quantitative Economics. Since its inception, eminent scholars from all over the world have been contributing research articles for publication in *Sankhyā*, one of the most prestigious and internationally renowned journals.

Journal Committee :

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

Co-Editors : Series A : Arup Bose, Mohan Delampady, Kesar Singh, R.L. Karandikar, P.K. Bhattacharya and Bimal K. Sinha.

Series B : Dipankar Coondoo, S.R. Mohan, T.J. Rao and Bikas Kumar Sinha.

Managing Editors : Series A : R.L. Karandikar
Series B : T.J. Rao

The following publications are published during April 1995 to March 1996 :

a) Sankhyā Ser. A : Volume 56, Part 3
Volume 57, Parts 1, 2, 3

b) Sankhyā Ser. B : Volume 56, Parts 2, 3
Volume 57, Parts 1, 2, 3

Other Publication

A biography of Prasanta Chandra Mahalanobis entitled 'Prasanta Chandra Mahalanobis : A Biography' is expected to be published shortly.

7. SCIENTIFIC PAPERS AND PUBLICATIONS

Books Published

Theoretical Statistics and Mathematics Division

Delhi Unit

Prakasa Rao, B.L.S. (ed.) : *Statistics and its Applications*, Indian National Science Academy, New Delhi, 1995.

Prakasa Rao B.L.S. and Bhat B.R. (eds.) : *Stochastic Processes and Statistical Inference*, New Age International, New Delhi, 1996.

Applied Statistics, Surveys and Computing Division

Computer Science Unit

Mukhopadhyay, Parimal : *Mathematical Statistics*, New Central Book Agency, Calcutta, 1996.

Physical and Earth Sciences Division

Physics and Applied Mathematics Unit

Roy, S., Jeffers, S., Vigier, J.P. and Hunter, G. (eds.) : The present status of Quantum theory of light , Kluwer Academic Pub., Netherlands, 1995.

Roy, S., Jeffers, S., Evans, M.W. and Vigier, J.P. : The Enigmatic Photon, Vol. III, Kluwer Academic Pub., Netherlands, 1996.

Biological Sciences Division

Anthropometry and Human Genetics Unit

Bose, A., Roy, B.C. and Gupta, R. (eds.) : *Challenges and Response*, Calcutta, Punthi Pustak, 1996.

Reddy, B.M. and Gupta, R. (eds.) : PC Mahalanobis Birth Centenary Symposium on Frontiers of Anthropology, *Special Section of Human Biology*, 1995.

Reddy, B.M. and Gupta, R. (eds.) : PC Mahalanobis Birth Centenary Special Issue, *J. Indian Anthrop. Soc.*, 1995.

Social Sciences Division

Economic Research Unit

Bhattacharya, N., Adhikari, A.K. and Chaudhuri, P. : *Report on the Pilot Survey of Income, Consumption and Savings - Part II* : NSS Report No.398, National Sample Survey Organisation, Government of India, 1995.

Chattopadhyay, M. : *Agrarian Structure and Peasant Mobilisation*, K.P. Bagchi and Company, Calcutta, 1996.

Economic Analysis Unit

Narayana, N.S.S. and Sen, Anindya (ed.) : *Poverty, Environment and Economic Development. Festschrift in honour of Prof. Kirit S. Parikh*, Interline Publishing Ltd., Bangalore.

Parikh, Kirit, Narayana, N.S.S., Panda, Manoj and Ganesh, A. Kumar : *Strategies for Agricultural Liberalization : Consequences for Growth, Welfare and Distribution*, IGIDR, Mumbai.

Linguistic Research Unit

Bandyopadhyay, Debaprasad : *Folklore and Folklanguage : Myth or Reality*. Kalyani University, 1995.

Psychometric Research and Services Unit

Gupta, Rumki, Chatterji, S. and Mukherjee, M. : *Examiner's Manual for Non-Language Test of Intelligence*, Manasayan, Delhi, 1995.

Sociological Research Unit

Bandyopadhyay, S., Sinha, B., Rao, T.J., Dasgupta, A. and Ghosh, A. : *Calcutta Book Fair, 1995 : A Sample Survey* (in Bengali), Ganashakti Printers Private Ltd., Calcutta, 1996.

Dasgupta, Atis : *Groundswell in Bengal in the 1940s*, National Book Agency, Calcutta, 1995.

Library, Documentation and Information Sciences Division

DRTC (Bangalore)

Malwad, N.M., Rajashekhar, T.B., Ravichandra Rao, I.K. and Satyanarayana, N.V. (ed.) : *Dynamic Storehourse of Digitised Information, Digital Libraries*, New Age International Publishers, New Delhi, 1996.

Seetharama, S. (ed.) : *Libraries and Information Centres, As Profit-Making Institutions*, DRTC, ISI, Bangalore, 1995.

Papers Published in Journals

Theoretical Statistics and Mathematics Division

Calcutta Unit

Bandyopadhyay, P. and Roy, A.K. : Extreme Contractions in $L(l_1^p, l_1^q)$ and the Mazur intersection property in $l_1^p \otimes l_1^q$, *Real Analysis Exchange*, 20, 681-698, 1994-95.

Basu, Srabashi, Raychaudhuri, A. and Basu, A. : Improving precision through modelling, *Communications in Statistics : Simulation and Computation*, 24, 399-408, 1995.

Basu, Srabashi, Park, C. and Basu, A. : Robust minimum distance inference based on combined distances, *Communications in Statistics : Simulation and Computation*, 24, 653-673, 1995.

Basu, Srabashi, Pugh, J.A., Medina, R.A. and Cornell, J.C. : NIDDM is the major cause of diabetic end-stage renal disease : More evidence from a tri-ethnic community, *Diabetis*, 44, 1375-1380, 1995.

Basu, Srabashi and Landis, J. Richard : Model-based estimation of population attributable risk under cross-sectional sampling, *American J. Epidemiology*, 142, 1338-1343, 1995.

Chaudhuri, Probal and Mykland, Per A. : On Efficient Designing of Nonlinear Experiments, *Statistica Sinica*, 5, 421-440, 1995.

Chaudhuri, Probal, Wen-Da Lo, Wei-Yin Loh and Ching-Ching Yang : Generalized Regression Trees, *Statistica Sinica*, 5, 641-666, 1995.

Dasgupta, Ratan and Bhaumik, D. : Upper and lower tolerance limits for atmospheric ozone level and extreme value distribution, *Sankhya*, Ser. B, 57, 182-199, 1995.

Datta, G.S. and Ghosh J.K. : Non-informative priors for maximal invariant parameter in group models, *Test*, 95-114, 1995.

Datta, G.S.and Ghosh J.K. : On priors providing frequentist validity for Bayesian inference, *Biometrika*, 82, 37-45, 1995.

Ghosh J.K., Dasgupta, A. and Sen, M.M. : A new general method for constructing confidence sets in arbitrary dimensions, with applications, *Ann. Statist.*, 23, 1408-1432, 1995.

Ghosh J.K. and Dey, Anindya K. : A decision rule for dimension in the context of MANOVA, *Sankhya*, Ser. A, 57, 256-266, 1995.

Ghosh J.K. and Mukherjee, R. : Frequentist validity of highest posterior density regions in the presence of nuisance parameters, *Statistics and Decisions*, 13, 131-139, 1995.

Ghosh J.K. and Mukherjee, R. : On perturbed ellipsoidal and highest posterior density regions with aproximate frequentist validity, *J. Royal Statistical Society*, Ser. B., 57, 561-769, 1995.

Lavery, L.A., Ashry, H.R., Ban, Hondum, W., Pugh, J.A., Harklets, L.B., Basu, Srabashi : Variation in the incidence and proportion of diabetics-related amputations in minorities, *Diabetis Care*, 19, 48-52, 1996.

Mulrow, C.D., Chiodo, L.K., Gerety, M.B., Lee, S., Basu, Srabashi and Nelson, D. : Function and medical comorbidity in South Texas nursing home residents : Variations by ethnic group, *J. American Geriatrics Soc.*, 44, 279-284, 1996.

Raha, A.B. and Kundu, S. : The bounded-open topology and its relatives, *Rendiconti dell Istituto Di Matematica dell Universita di Trieste*, 27, 1995.

Rao, A. Ramachandra : Reciprocity in marital and social networks : Illustration with Indian Data. *Human Biology*, 67, 887-904, 1995.

Rao, T.J. : Allocation of sample size in stratified populations, *Bull. Int. Statist. Inst.*, 50th session, Book 2, 1011-1012, 1995.

Rao, T.J. : Book Review of 'Statistical Methods - An Introductory Text' by Medhi, J., Wiley Eastern, *Sankhya Ser. B*, 57, 169, 1995.

Sinha, Bikas K. and Heiligers, B. : Optimality aspects of Agrawal designs, *Statistica Sinica*, 5, 599-604, 1995.

Sinha, Bikas K., Sinha, Bimal K. and Purkayastha, S. : Some aspects of ranked set sampling, *Biometrika*, 82, 1995.