Sixty Sixth Annual Report

APRIL 1997 - MARCH 1998

INDIAN STATISTICAL INSTITUTE

203 Barrackpore Trunk Road, Calcutta - 700 035

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17. Prof. Prabuddha Nath Roy, Pro-Vice-Chancellor (Academic), Calcutta University.
18 Prof. Ganesh Bhattacharya, Former Professor, DRTC, ISI, Bangalore.

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19. Shri Ajay Ghosh, Representative of the Scientific Workers.
20. Shri Sashi Kanta Mishra, Representative of the Non-Scientific Workers.

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26. Dr. M.K. Chakrabarti, Professor-in-Charge, Computer and Communication Sciences Division.
27. Shri Anup Majumder, Head, Statistical Quality Control and Operations Research Division.
28. Prof. K.B. Sinha, Acting Head, Delhi Centre.
29. Prof. Gadadhar Mishra, Acting Head, Bangalore Centre.
30. Dr. P.S.S.N.V.P. Rao, Dean of Studies.

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INDIAN STATISTICAL INSTITUTE

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203 Barrackpore Trunk Road
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Editorial Board

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BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early twenties through the pioneering initiative and efforts of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological and Anthropological Survey of India) and subsequent interactions with him led to 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 (ISI) was registered as a non-Government and non-profit distributing learned society on April 28, 1932, under the Societies' Registration Act No. XXI of 1860. The total expenditure in the first year was a meagre Rs. 238.00 and the number of workers was only two or three. From such a modest beginning, the Institute grew, under the remarkable leadership of Professor Mahalanobis, into an all-India 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, Mumbai, Pune, Coimbatore, Chennai, 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. *Sankhyā*, the Indian Journal of Statistics, was started in 1933 with P.C. Mahalanobis as its Editor, and received instant international recognition which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale sample survey. 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 Tagorei*, 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 theoretical and applied statistical work have culminated in the recognition of the Institute as an Institute of national importance by the Government of India through the Indian Statistical Institute Act, 1959. By the act the Institute was empowered 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.), Post Graduate Diplomas in SQC & OR and in Computer Science 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 which also received formal recognition from the All India Council for Technical Education (AICTE). Subsequently, a Master of Science programme in Quantitative Economics was also introduced. 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 was amended by the Parliament in September 1995 to empower the Institute to award

Degrees/Diplomas not only in statistics but also in mathematics, quantitative economics, computer science and such other subjects related to statistics as may be determined by the Institute from time to time.

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 view of these, the Memorandum of Association of ISI was updated first in 1976 and subsequently in 1995. The objectives of the Institute as laid down in the Memorandum of Association are :

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

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

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

The units of academic, scientific, project and administrative service activities of the Institute were regrouped into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 1996.

From the early days, the Institute has been 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 from 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, 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) at ISI in the year 1988. The Institute also has the infrastructure for providing the most modern computational environment with facilities for e-mail, internet connection, etc.

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 a 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.

With a view to developing innovative methodologies for collection and analysis of quality survey data, interacting and collaborating with organisations like NSSO, CSO, DoS, Planning Commission, RBI, etc., promoting the growth of inter-disciplinary research in statistics and data analysis in the Institute, and disseminating the methodologies (old and new) to the scientific, academic and research organisations, a Survey Research and Data Analysis Centre (SURDAC) has been established at the Institute in February 1997. Such a centre would benefit the planning processes and national development. In 1995, the Plan and Policy Research Unit (PPRU) was established under the Planning Unit at Delhi Centre which has already undertaken several projects of national and international importance.

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 National Board of Higher Mathematics (NBHM) has been developed out of the grants from the (NBHM). 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 Professor P. C. Mahalanobis Memorial Museum & Archives, which was inaugurated on June 29, 1993 by Shri P. V. Narasimha Rao, the then Prime Minister of India, has been established in *Amrapali* on the Institute campus in Calcutta.

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, receipt of national and international recognitions of very high order by the scientists of the Institute in terms of awards, titles, and fellowships, and holding of prestigious positions in various scientific organisations of higher learning as well as in governmental organisations both in India and abroad. With a dynamic group pursuing and guiding research work in some of the most modern topics in statistics, mathematics, computer science, economics and in various fields of natural and social sciences, there exists a close interaction among the scientists from all over the world

Director's Report

During the year 1997-98 training in core areas of Statistics, Mathematics, Economics, Computer Sciences and other related disciplines was in full gear. The scientific and technical workers kept a busy schedule with research activities, project works, case studies and professional activities both in theoretical and applied statistics as well as in other interdisciplinary areas. In the project "Development of Statistical Techniques as an Aid to Geological Mapping", the very important problem of developing a sampling scheme for allocation of optimum number of observation points to most appropriate solution has been taken up and answers to the questions of how many points to sample and where to sample have been answered. In the project "Projection of HIV Incidence in Calcutta" a preliminary study based on limited survey information on incidence of HIV in Calcutta has been completed and work related to pooling available data and more sophisticated analysis based on extensive epidemiological modelling is ongoing. This is the first time Statistical Projections of HIV-Infection are being made in the city of Calcutta.

The Plan and Policy Research Unit (PPRU) at the Planning Unit at Delhi has undertaken several projects of national and international importance which include : Impact of economic reforms on productivity of firms specially the steel industry; Inter-regional disparities and growth; Gender Bias and differential employment opportunities; Agricultural trade liberalisation and spatial development with focus on rural development; Promoting economic cooperation with ASEAN in the developing environment; and Do environmental regulations promote growth? The Survey Research and Data Analysis Centre (SURDAC) has taken up several interdisciplinary research projects covering areas such as Primary Education, Social Networks, Small Scale Industry, Cervix Cancer database, Biodiversity, Environmental Monitoring, Biometry, Air Pollution and also conducted a seminar series on "The Interface of Statistics & The Sciences - The SURDAC Experience".

The use of Statistical Quality Control and Reliability technique in controlling loss and cost and for improving and augmenting productivity in industries has generated great impetus to the quality movement in the Country. Professor Mahalanobis was a Messiah of Quality movement in India which was initiated at this Institute in 1947. The Institute with its expertise in the Quality Movement since the last 50 years is providing training and consultancy through its SQC & OR Units spread over the country in all areas of quality management and quality systems related to ISO-9000 certification.

The Quality and Reliability techniques developed by the Institute were and are being widely used in Japan for improvement of Quality of their products and management. Under the new economic scenario, in India it is absolutely necessary to use Quality techniques and systems implementation for our national development and welfare of the society. The Industry and Government of India should as far as possible implement these through the newly formed Quality Council of India with active participation by the Institute in this process.

During the year 1997-98, services for designing and implementation of ISO-9000 quality systems were rendered to 120 organisations. The crash programme for training of trainees undertaken by the Institute as the "Quality Mission Project" during the 8th five year plan has been well received by the Industry and a five fold increase in the number of participants in inplant training could be achieved by the SQC & OR Division during this period. This Project is being implemented during the 9th five year plan with some changes of focus, based on the recommendations of a peer group and accepted by the Section 8(i) Committee of the Institute, on training programmes and systems implementation to industries like Leather, Food Processing, Gems and Jewellery, Service Sector, Small Scale Industries, Environment and Quality System implementation for financial services including Banks, Health management etc. Efforts for export of our consultancy service have been initiated.

Research in Computer Science and related areas include incorporation of sex discrimination in genetic algorithms thereby showing a marked improvement over the conventional one in terms of both schemata and performance, integration of rough sets with fuzzy neural networks in soft computing paradigm for efficient knowledge encoding and rule generation, which also improves the speed and performance of the system. A pioneering development of a spell checker on Bangla has been achieved with a novel technique based on reversed word dictionary. The system can both locate and detect the spell error in word processing

most accurately. A new definition of Hausdnoff distance metric has been proposed in the fuzzy set theoretic frame work. A number of efficient parallel algorithms for various applications including numerical analysis, graph theory, signal processing, image processing have been developed by the parallel processing team of the Institute. The CAD tools developed by the VLSI team lead to cheaper, faster, more reliable and area efficient VLSI chips with complex interconnection structure. Important contributions have been made by colleagues in economic theory, international trade, econometrics, macro-economics and growth, industrial economics, planning, environmental economics, health sector reforms, dynamical systems, finance, poverty and agricultural economics.

The Institute also undertook several externally funded projects of national and international importance from different government and non-government organisations, including international organisations.

The Institute has been designated as one of the four Core Institutions in the country for the project "The implementation of the environmental economics component of the Environmental Management Capacity Building" undertaken by the Ministry of Environment and Forests, Government of India, with assistance from the International Development Association (IDA) of the World Bank. The project includes a number of components and one such area is environmental economics. The broad objective of the project is to strengthen the environmental management capacity of the country. The environmental economics component includes, among other things, development of model environmental economics curriculum, training economists as well as non-economists in environmental economics and support applied research in environmental economics. The duration of the project is five years beginning 1997-98.

A study on health sector reforms : An evaluation of impact and patterns of utilization among vulnerable groups in 3 Indian States (1997-2000) (Ministry of Health and Family Welfare, GOI and European Commission) has been taken up. The study is a response to expressed interest within the European Commission on health system research. The objective is to explore the extent to which a 'safety net' has been operational that protects the health needs of the most vulnerable groups by age, gender and socio-economic category. The study therefore intends, for the first time in a major developing country, to evaluate the health reforms, controlling for factors such as equity and allocative efficiency. Emphasis will be placed on methodological tools that are multi-disciplinary and incorporating epidemiology and health economics for the purpose of a comprehensive perspective. The States (e.g., West Bengal, Tamil Nadu and Andhra Pradesh) are selected on the basis of levels of socio-economic development that are to some degree comparable.

The other externally funded projects which emphasise the fact that Statistics is a key technology and is an interdisciplinary research and theoretical as well as applied science include Tracer Study of ITI Graduates (Ministry of Labour, GoI); Indepth Studies on the levels of development of Scheduled Castes and Scheduled Tribes (Ministry of Welfare, GoI); Development of spell-checker and morphological processor in an Indian Language with speech output for the blind (DOE, GoI); Development of a real time intelligent decision support system for range safety (DRDO); Software development for Cryptanalysis (DRDO); A neuro-fuzzy image recognition system : Methodology development for forensic applications (CSIR); A study of mathematical techniques in water wave problems (CSIR); Development of Statistical Techniques as an Aid to Geological Mapping (CSIR); Cancer Management in Soft Computing Paradigm (CSIR); Studies of the PBL dynamics using sodar and tower data and to predict a scalar transport model for the monsoon periods (DST); Development of computer algorithms for recognition and interpretation of sodar patterns (DST); Large amplitude ion & electron acoustic waves in relativistic plasma (DST); A neuro-fuzzy image based framework for diagnosis and therapeutic planning using multimodality medical imaging (DST). Development of methodologies for self organizing fuzzy logic controllers with special emphasis on neuro-fuzzy techniques, genetic algorithms and stability analysis (DST); Bilingual (Bangla and Devanagari) OCR system development (DST); Unsteady surface water waves in Ocean (UGC); Compilation and Optimization for Reconfigurable Co-processors (IRISA, France); Savings and Investment intermediation in the Indian economy - A structural vector auto regression model (RBI); Evaluation of rainfed farming project (ODA, UK); Change in livelihood trajectories (UEA, UK); Sustainable livelihood studies under environmental stress in eastern plateau of India (UEA, UK); Rice based cropping system studies in rainfed regions of Eastern Indian Plateau (IRRI); Development of CAD tools for identification of (i) logical equivalence of library elements & (ii) identification of false path in a switch level network (Motorola & IIT, Kharagpur); Genomic Diversity in Indian populations, Investigations through bio-technological tools in Eastern Indian populations (Ministry of Science and Technology, DBT); Molecular epistasis and the human globin gene clusters with special reference to

haemoglobinopathies in Eastern India (DBT, GoI); Genetics of quantity traits of commercial importance of the silkworm (CSB); Survey of possibilities and problems of small industries in Birbhum district (Govt. of W.B.); Total Literacy Campaign (TLC) project in Calcutta Municipal Corporation area (CMD); TLC project in Purulia district of West Bengal (Govt. of W.B.). Evaluation of continuing education in the district of South 24-Parganas (Govt. of W.B.); Algorithm development for natural language processing (IILCA, Tokyo University of Asian Studies, Japan); Algorithm development for pattern recognition & image processing of biomedical pictures (GDF, Munich, Germany); Mid-term review of family welfare project IPP-VIII, Calcutta (CMDA).

In appreciation and recognition of the high standards of research and scientific excellence maintained by the researchers and scientists of the Institute, several faculty and scientists of the Institute received laurels in the form of awards and fellowships from institutes/organisations of national and international repute.

Professor J.K. Ghosh, Jawaharlal Nehru Professor and Professor K.R Parthasarathy, INSA C.V Raman Professor, continue to be with us by providing academic leadership at Calcutta and Delhi centres of the Institute. Honorary Professor N. Bhattacharya was the President of the Statistics Section of the Indian Science Congress 1997. Several other colleagues and young faculty and young scientists received young scientists award and fellowship, membership, Associateship awards from scientific bodies such as INSA, Indian Academy of Sciences etc.

It has been a practice of the Institute to share its expertise and its facilities with colleagues and scientists, researchers and teachers from other Institutes, Universities, Colleges and Research and Scientific organisations. Following this view, various conferences, summer/winter schools, symposia, seminars workshops were held during the year to disseminate results obtained as well as to strengthen the research, project works, case studies and consultancy and professional work of the Institute with fresh ideas and methods. Several international conferences/workshops were held during year 1997-98 (Golden Jubilee year of Independent India) which emphasise the *Role of Statistics as a key technology*.

The Stat-Math Division and the Applied Statistics Division in collaboration with other Divisions organised a mammoth and successful international conference, "Recent Advances in Statistics and Probability", jointly with the Bernoulli Society for Mathematical Statistics & Probability. The Conference was the biggest of its kind in the country with 232 registered participants from 14 countries around the Globe. This was followed by a Satelite Bayesian Conference by Stat-Math Unit, Calcutta.

The Machine Intelligence Unit conducted an International Workshop on "Soft Computing and Intelligent Systems" at Calcutta. A workshop on "Computing and Communications Technologies" was organised by the Applied Statistics Division jointly with CICT Mumbai at Calcutta. This resulted in a new Multimedia project for development of lectures in statistics for students at the Higher Secondary level. The Computer Vision and Pattern Recognition Unit conducted an International conference on "Computational Linguistics, Speech and Documentation Processing" at Calcutta. Others by Stat-Math. Unit include Winter School on "Statistical Methods in Social Sciences", sixth discussion meeting on "Harmonic Analysis", UGC Refreshers Course (PG level) at all India level, Regional and National Mathematical Olympiads, "The Interface of Statistics and the Sciences : The SURDAC experience" at Calcutta and the Nurture programme of the NBHM for Indian National Mathematical Olympiad students at Bangalore. A seminar on "Mathematical Programming and Economic Theory", and a conference on "Recent Advances in Quantitative Methods with applications to Indian economic studies" by Economic Analysis Unit, Bangalore Centre, an Annual Conference on "Economic Theory and Policy" by Planning Unit, Delhi Centre, a Winter School on "Linear Complementarity Problems and Game Theory" and a workshop on "Statistical Process Control Methodology and Applications" by SQC & OR Division at Delhi Centre, a national symposium on "Methods in Quantitative Linguistics" by Linguistics Research Unit, at Calcutta, a Winter School on "Human Genetics : Concepts, Paradigms and Methods" sponsored by DBT (GoI) jointly with Indian Institute of Chemical Biology (IICB) at Calcutta by the Anthropology and Human Genetics Unit. This winter school was very timely because the DBT has recently taken up two national initiatives on Human Genome Research and Human Genome Diversity.

Regarding the teaching and training activities of the Institute, during the year 10215 candidates applied for admission to various courses offered by the Institute including B.Stat. (Hons.), M.Stat. (M & S Streams),Master of Science in Quantitative Economics, M. Tech (Computer Science), M. Tech.(Quality,

Reliability and Operations Research) etc. A total 6833 candidates finally appeared for the admission tests conducted at 21 different centres all over the country. A total of 481 candidates qualified for interview for final selection. Based on the academic record, performance in the written tests and interviews, a total of 226 candidates were offered admission to various courses leading to the degrees and diplomas during the academic session under review. It may be mentioned here that encouraged by the recent amendment of the ISI Act 1959, by the Parliament of India in 1995 which empowers the Institute to award degrees and diplomas not only in statistics but also in mathematics, quantitative economics, computer science and such other subjects related to statistics as well as to meet some of the needs of the country for development of human resources and research, a two year Master Degree Course in Quantitative Economics was introduced by the Institute in 1996 and the first batch of students will be completing their course in May 1998.

Recruitment of faculty, essential scientific, technical and administrative staff based on the minimal needs of the Institute is in progress. Academic leave rules are being formulated in the Institute. Further the Council of the Institute adopted revision of the rules of the Institute governing scientific works financed by bodies other than the Institute. Certain Medical benefits for the retired colleagues of the Institute will be introduced soon.

The International Statistical Education Centre (ISEC) is run by the Institute as an associated body/institution under the Memorandum of Association of the Institute jointly with the International Statistical Institute under the sponsorship of the UNESCO and the Government of India since 1950. During 1997-98 the Centre conducted its fifty-first term with 14 foreign trainees. The fellowships under the Special Commonwealth African Assistance Plan (SCAAP) of Govt. of India which were withdrawn from the ISEC during the last few years have been reintroduced.

As far as the Non-plan grant 1997-98 is concerned, enough increase has been given by the Government for payment of arrears to non-faculty workers, subsequent upon the revision of pay scales based on the Fifth Central Pay Commission and the Government of India decisions in this regard, by the Council. Negotiations are going with the Government regarding upgradation of two scales for the non-faculty workers. However, the faculty pay scales have not yet been finalised by the Govt. and the Institute. Negotiations are also going on in this regard with the Government. The approved plan budget for BE 1998-99 is slightly lower than that for BE 1997-98.

Construction of the New Guest House, a long felt need, at Calcutta has been completed in December 1997 and several international, national conferences/workshops held during Dec '97 and March '98 used this facility extensively. An additional floor of the hostel building at Bangalore Centre has been constructed. The construction of an Administrative Building at the Delhi Centre is in progress. Equipment for modernisation of the printing press has been brought. Upgraded Internet connections for research work was installed at Calcutta, Delhi and Bangalore Centres of the Institute. The campus wide networking at Calcutta using optical fibre is in progress and is expected to be completed in the year 1998-99. The PCM Museum & Archives is expected to be completed in the financial year 1998-99. Several new constructions including those of faculty quarters, bank and post-office building, new academic building and canteen building have been started.

Passion for Quality should permeate all aspects of human life and organisations. In the new environment, the Institute has a dynamic role to play for furtherance of the excellence of the Institute, also in the emerging areas of research especially relating to the national development, social and human welfare. Our Institute is nationally and internationally recognised as a centre of excellence both for its contributions to theoretical statistics, mathematics, economics and computer sciences and other interdisciplinary research areas in natural and social sciences as well as to their applications. We all pledge to uphold the standards and keep the banner of recognition high. "WORK IS WORSHIP", "PASSION FOR QUALITY", "UNITY IN DIVERSITY" should be our mottoes.

March 31, 1998 (S. B. RAO)

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

I. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities of the Teaching and Training Division during the period from April 1997 to March 1998 is given below:

During the academic session 1997-98, a total of 10215 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), Master of Science (M.S.) in Quantitative Economics, M. Tech. in Computer Science, M.Tech. in Quality, Reliability and Operations Research, Two-year Part-time Post-Graduate Diploma in SQC and OR (Chennai), Research Fellowships in Statistics, Mathematics, Economics, Computer Science and Communication Sciences, Theoretical Computer Science, Theoretical Physics and Applied Mathematics, Anthropology, Geology, Sociology, Biometry and Statistical Quality Control and Operations Research, 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 6883 candidates finally appeared for admission tests and a total of 481 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 226 candidates were offered admission to various courses during the academic session under review.

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

The annual examinations for all the regular courses were held in May-June 1997. The 1997-98 academic session commenced on 1st July, 1997.

The number of candidates admitted to the different degree, diploma and training courses in 1997-98 and the number of students passed in the annual examinations in 1997 are given below.

Forty five trainees in Engineering and Technology from various Universities (Motilal Nehru Regional College, Allahabad, Regional Engineering College, Kurukshetra, Institute of Radio Physics & Electronics, Calcutta University, Jadavpur University, Regional Engineering College, Durgapur, Birla Institute of Technology, Ranchi, Regional Computer Centre, Calcutta, Regional Institute of Technology, Jamshedpur, Indira Gandhi Institute of Technology, Orissa, Regional Engineering College, Rourkela, Regional Engineering College, Roorke, Assam Engineering College, Guwahati, College of Engineering Technology, Bhubaneswar, Indira Gandhi National open University, Calcutta, University College of Engineering, Sambalpur, Deptt. of Computer Science, Tezpur, Assam, Tezpur University, Assam, Deptt. of Science and Application, Utkal University, Bhubaneswar) received a two-week/six-week/six months M.C.A. Engineering/practical training in the different Computer Sciences Units of the Institute, viz., ECSU, CVPRU, CSSC, MIU and ACMU.

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

	Courses	Number of Students	
		Passed in the annual exam in 1997	Enrolled in 1997-98
	(1)	(2)	(3)
Degrees			
1.	Bachelor of Statistics with Honours [(B.Stat)(Hons.)]		
	1st year	13	23
	2nd year	36	13
	3rd year	29	36
2.	Master of Statistics (M.Stat.)		
	1st year (M-stream)	–	8
	1st year (S-stream)	34	34
	2nd year	53	28
3.	Master of Science in Quantitative Economics (M.S.)		
	1st year	15	20
	2nd year	–	15
4.	M.Tech. in Computer Science		
	1st year	26	26
	2nd year	21	26
5.	M.Tech. in Quality, Reliability and Operations Research		
	1st year	12	15
	2nd year	12	12
Certificate/Diploma			
6.	Course on Operation and Programming of Automatic Data Processing Equipment		
	1st year	14	15
	2nd year	12	14
7.	Part-time Certificate/Diploma Course in Statistical Quality Control and Operations Research		
	Chennai - 1st year	–	–
	2nd year	5	6

	(1)	(2)	(3)
8.	Course in Documentation and Information Science (Bangalore)		
	1st year	6	5
	2nd year	8	6
9.	One Year Part-time Course in Statistical Methods and Applications		
	Calcutta	9	23
	Delhi	8	–
	Hyderabad	9	43
10.	Six-month Part-time Course in Statistical Quality Control		
	Bangalore [July.-Dec. 1996]	17	23
	Bangalore [January - Dec. 1997]	15	17
	Hyderabad [July - Dec. 1996]	12	24
	Hyderabad [July - Dec. 1997]		31
11.	Intensive Course in Programming and Applications of Electronic Computers	12	19
12.	(a) Statistical Assistantship [Nov. 1997]	–	3
	(b) Junior Diploma in Statistics [April 1997]	–	40
	(c) Senior Diploma in Statistics [Nov. 1997]	–	11
Fellowships			
13.	Junior and Senior Research Fellows, and and Research Associates in different disciplines	8	15*
	GRAND TOTAL	386	551

*Number of scholars who joined in 1997.

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 Governemin of India. The Centre functions under a Joint Board of Directors. Professor P.C. Mahalanobis was the Chairman since the inception of the Centre in 1950 until his death in 1972. Since then Professor C.R. Rao has been the Chairman of this Board. During 1997-98 the Board of Directors consists of Chairman : C.R. Rao. Member : (1) W.R. Vanzwet, President, International Statistical Institute (ISI), Netherlands. (2) M.G. Ottaviani, President, IASE. (3) M.P.R. Vandenbroecke, Director, International Statistical Institute. S.B. Rao (Director, Indian Statistical Institue) and P. Mukhopadhyay (Member-Secretary) of the Indian Statistical Institute.

The Centre provides training in Thooretical and Applied Statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia., the Far East and the Commonwealth countries in Africa.

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

ISEC successfully completed its training program of 51st term of Regular Course. This year, there were fourteen trainees from eight countries viz. Sri Lanka (3), Maldives (2), Philippines (2), Cambodia (2), Bangladesh (1), Bhutan (2), Korea (1) and Myanmar (1). The Centre organised a study tour of the trainees to Darjeeling in December last year.

During the period under review, Mr. M. Jashimuddin of Commonwealth Secretariate, London visited the Centre during 10 -12 June, 1997. Dr. S. Stanley Young, Fellow, American Statistical Association visited the Centre during 6 - 8 January 1998. Dr. Carles M. Jarque, President of the National Institute of Statistics, Geography and Informatic (INEGI) Mexico visited the Centre during 2 -3 March, 1998.

The applications have been sought from different countries through Indian High Commissions abroad for admission to the next session commencing June, 1998 and these are at various stages of processing at present.

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

By the decision of the Academic Council and Council of ISI, new registration for Statistical Assistantship Certificate examination were discontinued from July 1995.

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

The Government of India recognises the Junior Diploma in Statistics as equivalent to 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 or about the months of April/May and November/December at different cities in India (Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras).

The total number of candidates and their results for April 1997 and November 1997 term of the examinations are shown below. The May/June 1998 term examinations are under process. The examinations will be held about last week of May or 1st week of June 1998. Hence shown below are the nos. of total registerod Candidates for November 1997 term**.

Examinations	Number of Candidates					
	Registered		Appeared		Passed *	
	April 1997	Nov. ** 1997	April 1997	Nov 1997	April 1997	Nov 1997
1. Statistical Assistantship Certificate	4	3	4	3	3	1
2. Junior Diploma in Statistics	66	69	40	28	11	16
3. Senior Diploma in Statistics	10	11	5	5	2	2

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

Preparation for the next term Professional Examinations scheduled to be held in May/June, 1998, 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 Diplomas in the Professional Examinations in Statistics including the result of November 1997 term are 488 and 280 respectively.

2. 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 organizations 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 Division, Physics and Earth Sciences Division; Computer and Communication 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, e-mail and internet facilities and provides computing and statistical services 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 Council of the Institute reorganized the divisions and also the different units belonging to the respective divisions a few years ago.

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 in 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 Ph.D degree of the Institute. The unit in 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 from 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 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 organizations.

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

Calcutta Unit

Research Activities

Mathematics

General, Algebraic and Differential Topology, Topology with emphasis on Function spaces, Commutative Algebra, Equivariant plus construction and acyclic maps, Gromov theory on partial differential relations, Uncertainty principles on Nilpotent and Solvable Lie groups, Wiener Tauberian Theorems in Semisimple Lie Groups, Equivariant Cobordism, Stochastic Differential Geometry, Descriptive Set Theory, Automata Theory, Theoretical Computer Science, Harmonic Analysis, Ergodic Theory, Functional Analysis, Geometry of Banach Spaces, Differential Geometry, Graph Theory and applications to Social Networks, Combinatorics and Construction of Designs.

Probability Theory and Stochastic Processes

Limit theorems, Rates of convergence and expansions, Stochastic Integrals, Markov Processes and Dynamical Systems, Stochastic Differential Equations, Random Walks, Finitely Additive Probability,

Probability inequalities and Stochastic majorisation, Martingale theory and Stochastic calculus, Markov chain simulation, Percolation Theory.

Theoretical Statistics

Asymptotic theory in Statistics, Sequential Analysis, Bayesian Inference, Ranking and Selection, Cramer-Rao type Integral Inequalities, Multivariate Analysis, Non-parametric Inference, Inference in Stochastic Processes, Directional Data Analysis, Optimal Designs and other aspects of experimental designs, Survey Sampling, Survival Analysis, Time Series Analysis, Bootstrap, Jackknife and other resampling techniques, Parametric and nonparametric regression techniques and related topics, Bayesian nonparametric statistics and estimation, Bayesian semiparametric inference and inference with many nuisance parameters, Robust Bayesian Analysis, Reliability theory, Applications of Statistical and graph theoretic techniques to Social and Biological Sciences.

Some major contributions from this unit are as follows.

Mathematics

A structure theorem for finitely generated locally A^*-algebras over noetherian domains has been proved.

Minimal sufficient fibre conditions for a finitely generated flat algebra over a noetherian normal domain to be locally A^* has been given. A salient feature of this result is that conditions on merely the generic and codimension one fibres are assumed.

The structure of a finitely generated overdomain of a discrete valuation ring whose generic fibre is A^* and closed fibre is geometrically integral has been described. The problem of A^* fibration over general noetherian domain has also been investigated with examples.

Theory of Function Spaces : The interplay of functional analytical and measure-theoretic results in function spaces were used to determine intimate connections between topological and analytical facts. Some new revealing results have been obtained.

A sufficient criterion for a manifold with $Z_2 \times Z_2$ action with isolated stationary points to be a boundary has been obtained. The criterion can be used to determine cobordism classes for many manifolds satisfying the condition. An example is explicitly discussed to show how the above result can be used.

A joint research project with P. Sankaran (SPIC) is going on. The main problem being tackled is to determine which Grassmann manifolds are nilpotent spaces. Nilpotent spaces are very useful in localization problems.

Work continued on asymptotic norming (and associated w^* asymptotic norming) properties of Banach spaces introduced by R. C. James which has intimate connections with the Radon-Nikodym property in Banach spaces.

U-subspaces of Banach spaces and their connections with w^* asymptotic norming properties were examined. This leads to many refinements of the Hahn-Banach theorem in various contexts. The work is still in progress.

Extensions and localization of earlier results on nicely smooth Banach spaces have been obtained. Some conditions for a space to be nicely smooth were obtained, and their equivalence for separable or Asplund spaces was shown, which sharpen known results. Nice smoothness of certain operator spaces has been studied and the striking result that every equivalent renorming of a space is nicely smooth if and only if it is reflexive, has been obtained.

A recent work of L. Vesely in which Banach spaces that admit weighted Chebyshev centres for finite sets, was examined. In this connection, the notion of central subspace of a Banach space was introduced and

it was shown that the so-called L^1-preduals have this property. Certain stability results for spaces of vector-valued continuous and Bochner integrable functions were also obtained.

In a subsequent work some of Vesely's optimization results have been extended to larger classes of sets. Subspaces with relative intersection properties with the centres of the balls coming from finite, compact, or bounded or arbitrary sets have also been defined. The first of these defines central subspaces and the last one is related to the Finite Intersection Property (FIP). Extensions were obtained of some earlier results in this general set-up.

Harmonic analysis on Step Two Nilpotent Lie groups has been done in more explicit terms than known before. This has resulted in some analogues of the classical uncertainty principles and the Heisenberg inequality.

Work is being carried on on approximate algorithms for selected NP hard optimization problems such as max-cut, linear ordering and related problems.

Work was done on Cellular automata and Neighbourhood Logic.

In Graph Theory and its application to social networks, various aspects of the social network of a village in Birbhum district in 1970 were studied. A comparison with the situation in 1998 revealed interesting changes like many-fold increase in ties outside the village, disintegration of the large cliques balanced by increase in connectedness, etc.

Markov Chain Monte Carlo methods were developed to generate random networks and random partitions of a set.

Stochastic Processes

Part of the work on infinite-dimensional stochastic calculus - connecting the formulae of Ito and Tanaka using Schwarz distributions - is now complete. The results were presented at the Bernoulli conference in December, 1997.

Hewitt-Savage zero-one law in Strategic set-up was discussed. A detailed analysis of completeness of L_1 spaces over finitely additive probabilities was carried out.

Theoretical Statistics

Work was done in the areas of : Bayesian testing, model selection and analysis of infinite dimensional problems, history of evolution of statistics in India, AIDS forecast, estimating the number of birds in an area based on birdsightings, geological mapping, and modelling transport of sediments.

A graphical technique for assessing statistical significance of observed structures in curve estimates constructed from noisy data has been developed. The methodology is based on some fundamental ideas from the scale space theory in computer vision and non-parametric statistical smoothing procedures.

Projection of HIV infection in Calcutta : Starting with the base year of 1991, projections of HIV infection to 1999 for the total population, as well as various high-risk sub-populations of Calcutta were provided. The methodology for the study of the spread of HIV infection takes various social interactions and practices into account, and also uses data that are already available. Rates of these interactions and practices and estimates of demographic parameters used in making projections were obtained primarily from surveys and census data. This is the first time statistical projections of HIV-infection are being made for the city of Calcutta. The total projection of the number of HIV infected cases in Calcutta for 1999 is between 49,000 and 1,26,000 (approx). Separate projections are also provided for high-risk sub-groups. Among these sub-groups, the sex-workers expectedly will continue to manifest the highest numbers of newly infected cases. What is, however, alarming is that the temporal rate of increase in prevalence is projected to be higher in the general population than even among sex workers, although the actual prevalence will continue to be the lowest in the general population compared to all other sub-groups of the population.

Words in DNA sequence : Some case studies based on their frequency statistics : Sequence alignment and homology techniques that are quite popular for comparing and analyzing relatively smaller DNA sequences of nearly equal sizes are not applicable to data consisting of large sequences with widely varying sizes. Besides, large DNA sequences may contain segments with unknown or no biological functions, and this makes their comparison through functional homology either impossible or extremely difficult. One of the critical requirements of data analysis involving large DNA sequences is an effective statistical summarization of those sequences. In an article, DNA sequences have been analyzed based on word frequencies. The analysis mainly focuses on statistical detection of the structural signature of a genome reflected in word frequencies and identification of phylogenetic relationships among different species reflected in the variation of word distributions in their DNA sequences. The exploratory analysis conducted amply demonstrates the usefulness of DNA word frequencies in reducing the dimensionality of large sequences while retaining some of the fundamental structural information. Frequencies of DNA words appear to be quite useful in exploring structural patterns that are intrinsic of specific genomes as well as in unmasking phylogenetic relationships among different species. Some conceptual issues that arise in course of the investigations have been addressed, and a few interesting problems related to the statistics of DNA words have been pointed out with some indication of their possible solutions.

On Homogeneous elliptic clusters in multivariate data based on Mahalanobis' distance : A new algorithm for partitioning a set of objects into homogeneous groups has been developed that blends key features of hierarchical clustering and optimum partitioning algorithms used in cluster analysis. Several quantitative characteristics of a given partition have been proposed and studied, which can be used as indicators for the amount of homogeneity and heterogeneity present in the sets of the partition. An adaptive data based approach for choosing the optimal number of homogeneous groups and an estimate of the common intra-cluster dispersion matrix based on the optimal partition of the multivariate data have been suggested. The new method is applied to three data sets and the resulting partitions are evaluated using certain homogeneity and heterogeneity indices that provide useful insights into the performance of the clustering algorithm developed.

Exact Minimum Disparity inference in complex multinomial models : Estimation of the probability vector in a multinomial set-up is an important practical problem. Under moderate contamination several minimum distance estimators of the Cressie-Read family of disparities are superior to the maximum likelihood estimator. However, it has also been observed before that when an empty cell penalty is introduced, the above mentioned estimators show marked improvement in their efficiencies compared to the maximum likelihood estimator. The role of different penalties in reducing the mean square errors of the estimators and in improving the chi-square approximation of the penalized test statistics have been studied.

Some interesting results were obtained in the following areas : (a) Inequality between various order statistics for certain symmetric unimodal distributions. (b) Ranked set sampling and loss function. (c) Use of mixture models in pattern recognition.

A problem about order statistics of normal i.i.d. samples and another (a twenty year old) problem of Pitt (1977 Ann. of Prob.) regarding association of symmetric convex sets in R^n with normal (i.i.d) probability have been solved. Some work has been done on self-organising maps as well as pattern recognition.

A general method of construction of symmetrical as well as asymmetrical orthogonal arrays of strength 2 and higher has been obtained. An interesting application leads to some series of tight orthogonal arrays. Some results on resolvable incomplete block designs have also been obtained.

Families of universally optimal Diallel/Triallel Cross designs are obtained. These are all complete diallel designs. MS optimal partial diallel cross designs have been characterized and series of such optimal designs obtained. The designs have high A- and D-efficiencies.

Optimality of proper efficiency balanced designs having two types of replications have been studied and an exhaustive list of such optimal designs along with constructions tabulated.

Work on allocation problems in stratified sampling continued. Utilization of auxiliary information for estimation of population total by the use of ratios is explored further.

Research work on the problems related to the following main topics has also been taken up : (a) Estimation of mean vector for finite populations and domains. (b) Non-response in multivariate sampling. (c) Determination of optimum probabilities of selection based on multivariate information. (d) Estimation of transition probability matrices related to occupational and educational mobility based on complex designs, and (e) Model based survey sampling. The results obtained have important practical applications and are quite useful for some economic, demographic and agricultural studies.

Publication of Sankhya

The unit renders necessary assistance to Sankhyā office for publication of Sankhyā (A&B).

Projects Undertaken

Homogeneity and Hierarchical Structures

Last year a research project was undertaken in the Stat-Math Unit on Statistical Exploration of Homogeneous and Hierarchical Structures in the data. Main focus of the project is on Phylogenetic Analysis of various nucleic acid sequences available in DNA Data Bases that are accessible through the Internet. Some significant progress has been made towards development of novel statistical methodology for efficient analysis of large volumes of genomic sequence data.

Development of Statistical Techniques as an Aid to Geological Mapping (funded by CSIR)

The aim of the project is to provide a statistical method for geological mapping with a view to aiding and hopefully partially replacing the existing techniques which depend a lot on the geologist involved.

A simplified version of the geological mapping problem was considered in the initial stage. The problem was to divide up the area (to be mapped) into "homogeneous" subregions on the basis of the rock types and the object was to provide an automatic Bayesian solution to this problem. A model already set up for the available data (collected earlier in the study area of Bhimaram in the Godavari valley, India) gives the subregions into which a given set of boundaries partitions the whole area. Thus the problem of choosing a set of boundaries between "homogeneous" subregions corresponds to selecting one of several possible models. Recently developed automatic Bayesian methods of model selection were employed to solve the problem.

The very important problem of developing a sampling scheme for allocation of optimum number of observation points to locations that are most appropriate, has also been taken up. This answers the important question of where to sample and how many to sample.

In addition to the above projects, the faculty of the Stat-Math Unit also collaborated with the faculty of the Population Studies Unit, Sociological Research Unit and the Biochemistry Unit of the Institute on projects funded by SURDAC, the Survey Research and Data Analysis Center of the Institute. Work was done on the projects entitled "Changing Social Relations : Social Network Approach" and "Cervix Cancer Data Base Molecular Epidemiology."

An INSA-funded project entitled "Studies of Mathematical and Probability Inequalities" has started.

Regional Math Olympiad

The Regional Mathematical Olympiad 1997 for West Bengal sponsored by National Board for Higher Mathematics for students of Class IX, X and XI was organized on December 7, 1997 at various centers including Berhampore, Burdwan, Calcutta, Kalyani, Kharagpur, New Jalpaiguri and Purulia. The Indian National Mathematical Olympiad 1998 was held at I.S.I., Calcutta on February 1, 1998. This year Prof. S.M. Srivastava organized these. Over the years, these events have become very popular and led to great interest and enthusiasm in Mathematics in the region.

Delhi Unit

Research Activities

Statistics

Optimum design for diallel cross experiments and fractional factorial design. Estimation of a common mean. Associated random variables : general method of density estimation. U-statistics-their strong law of large numbers and central limit theorem. Wavelets : estimation of integral of square of a density and integral of square of derivative of a density. Distributions with periodic failure rate. Cramer-Rao inequalities in Banach spaces. Semi-matingales and statistical inference. Stochastic orders. concomitants of order statistics.

Probability and Mathematics

Characterisation of stochastic processes. Multivariance and multicorrelation. Covariance identities. r-th order strong mixing. Uniform approximations for families of stochastic integrals.

Directed spanning trees. Backbends on the 2-dimensional planar lattice. Exit times for triangular simplices. Martingale problems. Stochastic control. Filtering Theory. Fiedler's results on eigen spaces of second eigenvalue of the Laplacian matrix of graph. Matrix and Operator Theory. Noncommutative differentiation in Operator Theory. Numerical Analysis and Quantum Theory.

Bangalore Unit

Research Activities

Probability theory

Quantum Probability. Applications of large deviations to Information theory. semi-stable measures and processes. diffusion processes.

Statistics

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

Mathematics

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

Some major contributions are as follows.

The Concept of majorisation has been utilised to prove the optimality of the following two classes of designs with regard to a large class of optimality criteria. in the general class.

(a) A class of strongly regular graph designs with k large compared to v. This includes semiregular and singular group divisible designs with $\lambda_1 = \lambda_1 + 1$ as well as many linked block designs.

(b) Group divisible designs with $\lambda_1 = \lambda_1 \pm 1$ and group size 2.

Bailey and Cheng recently proved the optimality of partial geometric group designs within the class of binary equi-replicate designs. This result has been extended to the class of all binary designs - equireplicate or not, under some parametric restriction.

In the literature of survey sampling of continuous population a large number of sampling strategies have been proposed. However, an optimal strategy seldom exists. Comparison of sampling strategies, in the absence of an optimal one, is thus a major problem of interest to survey statisticians. Therefore the problem of comparing the performances of some design unbiased sampling strategies of estimating the population mean w.r.t. measures of uncertainty under regression model, was taken up.

In the theory of Dynamical Systems, properties of one-dimensional unimodal maps on an interval of the real line were studied.

Work on asymptotics of reflecting diffusions continued.

A study of the partially ordered set of quantum dynamical semigroups dominated by a given semigroup has been undertaken. It is proved that such semigroups can be lifted for dilations and then they can be described through cocycles. Local cocycles of CCR flow can be computed. This helps one to show that minimal dilations of quantum dynamical semigroups with bounded generators can be realized through Hudson-Parthasarathy cocycles. A factorization theorem for a class of dilations has been obtained.

Hilbert modules over function algebras and quotient modules were investigated. Homogeneous contractions and their relationship with representations of Mobius group are being studied. The Nagy-Foias characteristic function of homogeneous contractions are being investigated. This has led to a complete classification of the contractions with a constant characteristic function. A product formula for the c.f. of homogeneous contractions, including representation of the Mobius group - leading to new interlinks between representation theory and operator theory, has been obtained.

A structure theorem for combinatorial pseudo-manifolds was obtained; this was applied to obtain a complete classification of the pseudo-manifolds with $n \leq d + 4$. It has been conjectured that pseudo-manifolds with the complementarity property are automatically manifolds - this conjecture is being investigated.

It was guessed that factorization theorems for the space $L^p(R^n)$ may be useful to prove a conjecture for some partial differential operators in $L^2(R^n)$. Work is continuing.

Research continued on various aspects of geometry of Banach spaces. Proximinality of the space of Bochner integrable functions w.r.t. a sub-sigma-field has been investigated.

Improving on a result of Grzaslewicz and Sherwentke, it was shown that there are no points of weak-norm continuity in the unit ball of the space of all operators on the space of integrable functions with values in a Banach space.

The generalized centres of finite sets in a Banach space were studied. It was shown that any Banch space whose dual is isometric to the space of integrable functions, admits centers for finite sets. Certain stability results for spaces of vector-valued continuous and integrable functions were obtained.

For a Banach space X whose second dual has the Radon-Nikodym property, it was shown that the dual of a subspace F of compact operators has the Schur property implies that the sets $\{T(x) : T \in F_1\}$ and $\{T^*(x^*) : T \in F_1\}$ are relatively compact, extending some recent work of Ulger, Saksman and Tylli.

Attempts are being made to prove pointwise ergodic theorems for certain one parameter family of probability measures associated to Gelfand pairs on the Heisenberg group using harmonic analysis techniques.

Ongoing research concerning Uncertainty principles in harmonic analysis on R^n and on Lie groups, and concerning application of harmonic analysis of questions in integral geometry/geometric analysis (in R^n as well as on Symmetric Spaces) were continued.

Research on determining the structure of the principal indecomposable modules of the group Sp (4, q) was carried out. Modular representation theory of the simple group G_2 (q) and the associated generalized Hexagon was studied.

Apart from continuing research activity in various areas of Mathematics and Statistics outlined above the department is actively involved in the efforts to promote quality teaching at the undergraduate level Mathematics. These include involvement in the "Nurture" programme of the N.B.H.M and the Mathematical Olympiad. A three week contact programme was held for the students of the Nurture programme at ISI-BC during July 1997.

Applied Statistics Division

Applied Statistics Division consists of only one unit viz. the Applied Statistics Unit.

Applied Statistics Unit

Scientists of the Applied Statistics Unit (ASU) are involved in multifarious activities related to teaching and training in the Institute. ASU is fully responsible for conducting the course "Intensive Course on Programming and Application of Electronic Computers". This unit also conducts several teaching/training programs like winter/summer schools and workshops. Some members collaborate with other units of ISI on joint projects. Currently, there are collaborative on-going projects with the Theoretical Statistics and Mathematics Division and the Social Sciences Division. The scientists of the unit are also actively involved in the activities of the newly formed SURVEY RESEARCH & DATA ANALYSIS CENTRE (SURDAC).

Research Activities

Sample Surveys

Optimal sampling strategies are derived to estimate total, variance and distribution function of finite populations using classical, hierarchical and empirical Bayesian approaches accommodating measurement errors in variables of interest and covering small domain problems. Relative performances of ordinary and generalized least squares estimators under error-component models in survey sampling and design of experiments are simultaneously evaluated. Methods of borrowing strength across domains and over time in order to develop serviceable small domain statistics are being explored further. Model assisted strategies for estimating finite population total and mean square error of estimator of total applying asymptotic methods are developed. Some asymptotically optimal double sampling procedures are also found. A new variance estimator in three-stage sampling is proposed and found to fare marginally better than a traditional one. In connection with an actual socio-economic survey based on a stratified unequal probability sample taken in three stages, confidence intervals are worked out for total, multiple and partial correlation coefficients and total and partial regression coefficients involving upto four variables simultaneously considered. Probability distribution of the number of distinct units in a PPS with replacement sample is worked out in a closed form in order to study the properties of a Rao-Blackwellized version of Hansen-Hurwitz estimator. Some progress has been made in the fieldwork for a survey project undertaken on small area estimation. In connection with a project on 'mangrove' in Lothian island of the Sunderbans some studies are made to work out appropriate shapes of plots in forest areas to appropriately estimate biomasses of plants. Properties are investigated of a general class of estimators of the ratio of two totals based on general complex sampling designs using multivariate data.

Design of Experiments, Combinatorial Methods and Their Applications

Cross-over designs are studied under non-additive non-circular models with carry-over effects of orders more than one. These models are general forms of the simple additive models which are currently used for studying cross-over experiments. Under these models, optimum designs are developed. It has also been shown that these optimality results remain robust under the corresponding model with random unit effects. The construction problem of these optimum designs is also completely solved.

A practical problem in the area of cross-over experiments is that all subjects may not be available for equal time-periods. Optimal cross-over designs are developed for experiments with arbitrary number of subjects studied over varying time-periods. Work is in progress in developing efficient designs which require the subjects to be tested over a small number of time periods.

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

Routing algorithms of street sweeper vehicles have been considered under various 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 ϵ-approximate algorithm has been developed for mixed graphs. Combinatorial aspects of designs are studied particularly with respect to characterizing the well known class of lambda designs. Some characterizations have been obtained under structural and parametric conditions.

Multivariate Analysis

A probability inequality applicable in 2 dimensions is shown to be true for higher dimensions in a special symmetric case. Minimum distance methods in multinomial models are being applied to study the effect of an empty cell penalty in minimizing the variance and the mean square of the estimator. Work is in progress on projection of HIV incidence in Calcutta. As an alternative to principal components analysis in reducing dimensionality efficacy of 'subset modeling' through proper conditioning on matrices is being explored - trying several alternatives with applications in regression analysis in the presence of multicollinearity. Work on semi-parametric classification rules subsuming the logistic discrimination rule of Cox is being done through a generalization of pseudo-MLE approach. Applications include many standard multivariate distributions and a variety of bivariate reliability models. Optimal tests are derived for no-contamination in multivariate mixture models. Neymann's $C(\alpha)$ - test is generalized to multiparameter two-sample case and its application to change-point problems is being studied.

Inference

Robust methods based on minimum distance techniques are being developed. New disparities are also being generated. New weighted likelihood procedures based on minimum distance estimating equations applicable in robust estimation and outlier detection are developed. Robust tests for equality of variances are developed. A new 'set estimator' useful in describing the external shape of a point set has been constructed.

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.

Progress has been made in developing robust procedures based on minimum distance ideas in i.i.d. situations as well as more general regression set ups. Recent advances include the development of a new class of divergences outside the scope of "disparities" and related inference. Other work includes new weighted likelihood procedures based on minimum distance estimating equations which can be used effectively both in robust estimation as well as in detection of outliers.

Linear Models

Some works that began as part of an ISI-funded project have been completed during this period. These include the various methods of diagnosing collinearity and dealing with it. Specifically, some diagnostics for the collinearity-influence of groups of observations were developed. The various methods to identify the groups of variables forming collinear relationships were studied, and their inter-relationships were examined. The theoretical question of 'how well-conditioned a subset of variables can be' was studied, and a few methods of identifying well-conditioned subsets were developed. The effect of location-change on collinearity was also studied.

A new approach to developing the theory of Best Linear Unbiased Estimation in the General Linear Model, based on Linear Zero functions, was developed earlier. The method yielded several advantages, including simplicity of derivation, and a clear understanding of the singular dispersion case. As a follow-up of this work, the updates in the General Linear Model for data and model changes were examined from this point of view. The new approach led to interesting interpretations of the correction terms, which bring out the uniformity of the underlying principles in the singular and non-singular dispersion cases.

Reliability, Life Testing and Survival Analysis

Studies are being carried out on the analysis of competing risk data with cause of death arbitrarily missing. Estimation procedures using EM algorithms have been worked out. A 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.

Maximum likelihood method for parametric estimation of the number of components in a system of superimposed renewal processes has been worked out. The same is being attempted in a non-parametric set-up.

Biostatistics

Distributional results have been obtained and methods of analysis developed for correlated, repeated observations on a single subject in dealing with skin papilloma.

The use of Markov chain method is being explored to analyze cancer data specially in dealing with heterogeneity in cell dynamics between animals.

A preliminary study on projection of HIV incidence in Calcutta based on limited survey information on incidence of HIV in Calcutta has already been completed. Work related to pooling available data and more sophisticated analysis based on extensive epidemiological modelling is ongoing.

Computer Science

(a) 2-D Cellular Automata

Algebraic properties of exceptional rules and also of one group of non-exceptional rules have been studied. A few results are derived on particular hybrid transformations.

(b) Design of Computer Networks

A reliability measure of a compute network is obtained using preliminary idea of information theory leading to a proposed dynamic design of a reliable computer network.

Projects Undertaken

A. Externally Funded

Tracer Study of ITI Graduates

Project Leader : Bimal Kumar Roy

Directorate General of Employment and Training, Ministry of Labour, Govt. of India requested ISI to conduct a study to assess the employability/self-employability of ITI certificate holders. Accordingly, the Applied Statistics Unit took up the study. 4 states viz. West Bengal, Delhi, Tamil Nadu and Gujarat were chosen for the study. For each state, 6 ITI's were chosen representing private, women's, Govt.-large and Govt.-small ITI's. For each chosen ITI, a sample of size not exceeding 125 was chosen from the list of all trainees who passed out in 1993 or 1994. The survey, data entry and data processing are already over. The report is at the final stage of its preparation.

Software Development for Cryptanalysis

Project Leader : Bimal Kumar Roy

The project is being taken up jointly with Bengal Engineering College. The duration of the project is two and half years and may be extended further. The aim of the project is to develop and implement cryptanalysis of LFSR based encryption scheme which uses a memoryless combining function. The methodology involves statistical techniques and the implementation requires efficient algorithms supported by special purpose hardware. The results of the project will significantly help the Systems Analysis Group of DRDO in their work.

Development of Statistical Technique as an Aid to Geological Mapping

Project Leader : J.K. Ghosh

Project Co-Ordinator : Tapas Samanta

After the location of boundaries in the first stage we took up the very important problem of developing a sampling scheme for allocation of optimum number of observation points for most appropriate locations. This answers the question of how many points to sample and where to sample.

B. Plan Projects

Applications of 2-D Cellular Automata

Project Leader : Pabitra Pal Chaudhury

Studies of various mathematical properties of nearest neighbourhood 2DCA transformations are continuing. We have divided them into various groups. The study of one of these groups concerning only two neighbours is near completion.

We have identified some exceptional transformations which do not match with others and thereby do not fall in any of the above groups. Their properties are being studied separately.

A class of hybrid transformations has been identified & their properties are being studied.

Small Area Estimation of Population for the Districts of Hugli and Murshidabad

Project Leader : Parimal Mukhopadhyay

No substantial progress could be made in respect of the project, "Small Area Estimation of Population for the Districts of Hugli and Murshidabad" in view of the fact that no suitable candidate has so far been found for the project-linked position of Data Processing Technicians.

Until now data have been collected from around 1000 households selected from 11 municipal area of the urban area of Hugli district consisting of 44 municipal and non-municipal areas. The scrutiny of the schedules and subsequent compilations are yet to be undertaken.

Software Package for Directional Data

Project Leader : A. Sengupta

This on going project is intended to develop software for various graphical aspects of recent interest in terms of behaviour of directional random variables, to incorporate some recent aspects of statistical inference e.g. change-point analysis, classification techniques, simulation etc. and to extend the work done on circular data to spherical data.

Applied Directional Data Analysis

Project Leader : A. Sen Gupta

This project is meant to establish the usefulness of Directional Data Analysis in various applied areas through real life data. Work on this has started only recently.

Optical Character Recognition (OCR) of Printed Telugu Script

Project Leader : C.H. Sastry

Selected Telugu text samples are digitized. Programs for scanning the text image for determining a threshold level in order to convert the image to a 2-tone image have been developed for segmenting the text image for lines and words. Studies are on to set up logical criteria to segment the characters. Many schemes are under consideration and experimentation. The problem of tilt correction is also being studied. Efforts are on to set up the infrastructural facilities required for the project.

Telugu Language Processing

Project Leader : C.H. Sastry

From the point of view of designing an OCR system for printed Telugu scripts, efforts are on to study the statistical characteristics of Telugu language, which is in common written use. For this purpose passages are being collected from popular Telugu magazines, news papers and children's literature. This is required for the purpose of collecting Telugu words used in different expressions of thoughts. Efforts are on to acquire facilities needed to store the passages in computer medium for statistical analyses later.

Analysis of Incomplete Life Time Data

Project Leader : Anup Dewanji

There have been extensive work involving incomplete life time data, examples of which can be found in almost all areas of applied sciences. We intend to concentrate on some specific problems with incomplete data as described in the following.

(i). Uncertain failure types in competing risks.

(ii). Non-availability of component life time data in a coherent system.

(iii). Superimposition of a number of independent and identically distributed (iid) point processes.

(iv). Only a surrogate process in available.

We would like to develop methodologies to carry out estimation and tests for relevant hypotheses, based on such incomplete data, and also to apply them to real data whenever available.

Presently, the following problems are being attempted :

(i). Nonparametric estimation of cause specific hazard rates in competing risks with missing failure types.

(ii). Nonparametric estimation of component life time distribution from observation on system life time in a coherent system.

(iii). Nonparametric estimation of a number of component processes in a system of superimposed iid renewal processes.

A Comparison of Robust Density-Based Minimum Distance Methods with Traditional Robust Procedures

Project Leader : Ayanendranath Basu

The project started in April 1997 and terminates in March 1998. Significant progress has already been made on a few papers dealing with certain aspects of the project, while work on a few others, still at an early stage, is expected to be completed within the project. A brief outline of the work under progress and expected to be completed is given below

Several aspects of the minimum distance procedures are explored in the work going on under this project. An algorithm for faster and efficient computation of the above minimum distance methods is being developed. A new class of robust tests for equality of several population variances based on the above minimum distance procedures has been developed A new class of density-based minimum distance estimators with bounded influence has been constructed. Theoretical verification of several empirically observed phenomena, such as the apparent 'bounded influence' type behavior of several minimum distance estimates in spite of their theoretical unbounded influence, and the empirically observed improved behavior of a class of 'penalized' minimum distance methods are also being attempted.

Analysis of Biomedical Imagery

Project Leader : Amita Pal

Focusing on imagery obtained from slides of peripheral blood, Bayesian and other paradigms are being implemented, initially on simulated images and subsequently on actual images, with a view to identifying different components and detaching at least some of the many possible abnormalities in them. Work an actual images has started only recently.

Workshop on Computer & Communication Technologies in Education

Project Leader : J.K. Ghosh
Project Coordinators : K.S. Vijayan, N.M. Singhi (TIFR)

An expository workshop on "Computer and Communication Technologies in Education" was be held at the Calcutta campus of Indian Statistical Institute during 19-20 January 1998. The workshop aimed at

creating an awareness regarding the rapid changes taking place in information technology, how this would affect education in general, how to make the best use of the emerging technologies for improvement in teaching and training and how quality education can be made available on a larger scale.

The Indian National Science Academy had organized a workshop in Delhi during October 1996 to look at some of these problems and a non profit organization "Consortium for Information and Communication Technology" (CICT) was formed to create awareness of the enormous opportunities and challenges that come with the emerging technologies. Some advanced workshops have already been held in Mumbai through CICT.

The workshop had lectures and presentations, dealing with themes like impact of computer related information technology on society, use of internet for providing extensive quality education, multimedia in training and preparation of course materials, Indian languages software and distance education.

Computer and Communication Sciences Division

The Division comprises Computer Vision and Pattern Recognition Unit, Advanced Computing and Microelectronics Unit, Electronics and Communication Sciences Unit, and Machine Intelligence Unit. Faculty members of the Division are also engaged in teaching and training M.Stat., M.Tech (CS) and M.Tech. (QROR) programs, in addition to their research and project works. Many undergraduate and postgraduate engineering students of Computer Sciences, 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 this division. Research works carried out in these units are described below.

Computer Vision and Pattern Recognition Unit

Research Activities

Document Analysis

Improvement in respect of style, font and size variations has been done on the existing Optical Character Recognition (OCR) system of printed Bangla.

(a) A robust technique for automatic skew-detection and correction for Bangla and Devnagari text has also been developed.

(b) Some statistics have been computed for Hindi language for OCR development on Devnagari script. A bi-lingual printed OCR system has been developed to read two most popular Indian scripts (Bangla and Devnagari).

(c) Since India is a multi-lingual country, it is important to develop a multi-lingual OCR. To start with, a system has been developed for automatic separation of Bangla, Hindi, English and Urdu scripts in a document.

(d) A document page may contain different types words like bold, italics, all-capital etc. An automatic, simple and fast method has been developed to detect these different types of words. The information can help to enhance the recognition accuracy of the OCR system as well as to extract important information from document which are printed in uppercase or bold and italic style.

Work on hand-printed Bangla character recognition is in progress.

Mathematical Morphology, Dot Pattern and Cluster Analysis

(a) Shape analysis of dot patterns is an interesting and important study in Pattern Recognition. A human observer is quick to understand the perceptual boundary of a point set under normal viewing condition when the points are clearly visible as well as fairly densely and homogeneously

distributed over a region. On the other hand, if the dot pattern is elongated or curvilinear then what we perceive as the shape is a linear form representing the skeleton of the pattern. Shape descriptors try to capture the same shape information from the dot pattern based on some hypotheses and computation.

(b) Two simple linear order (in terms of cardinality of the pattern) shape descriptors called s-shape and r-shape are proposed. The edges in s-shape are restricted only in horizontal and vertical directions, whereas the r-shape produces a smoother representation without any such restrictions in dge-directionality. A new structural basis called dispersion matrix is evolved from the s-shape. The binary image resulting from this dispersion matrix is successfully used to extract the skeleton of the dot pattern. Some efficient morphology based algorithms are also proposed.

(c) To take care of complex cases where the data density is varying in a single component, or where the patterns are overlapped, a new K-NN based clustering is proposed. The approach for detecting curvilinear dot patterns is also developed.

(d) The above problem may be viewed as a problem of set estimation given a finite number of sample points drawn from the set. A good set estimator (a) should be consistent, i.e. the Lebesgue measure of the symmetric difference of the actual region and the set estimator should go to zero in probability as the number of sample points increases arbitrarily; (b) should be computationally efficient; (c) should be automatic, in the sense that the method should be able to detect the number of independent disjoint components making up the true region and should not depend on this number being known and (d) should be robust in presence of additive noise. None of the currently known estimators combine all these properties. A s-shape based class of set estimators is developed which satisfy all the four properties. It is proved that the s-shape is a consistent estimator not just under the uniform distribution, but also when the points are drawn according to any continuous distribution. The order of error in estimation as well as computational complexity which is linear, is independent of the dimensionality.

Biomedical Image Analysis

(a) An automatic algorithm has been developed to segment 2-D cell images.

(b) A system for Automatic Analysis of the Three-Dimensional Histo-Pathological Images has been developed. The 3-D images are acquired using Confocal microscope in GSF, Munich, Germany, under the Indo-German Collaboration project on Algorithm Development for Bio-medical Image Processing and Image Database Generation. Various noise reduction, image enhancement and 3-D segmentation methods are developed and tested on Confocal image data sets. High level segmentation methods such as Active Contour Models or Snakes and Active-Volumes are designed and implemented. Region based techniques such as Automatic Seeded Volume Growing and Constrained Successive Erosion-Dilation techniques are implemented. A 3-D Watershed with an Automatic Detection and Merging of over segmented cells has been designed and implemented. Algorithms are developed for quantification of various Histo and Cytological features related to the carcinomic grades and/or pathological status of the issue specimen. Efforts for quantification of cell distribution based on Expectile Quantile plot and automatic subclassification of the volumetric data into different carcinomic grades are under progress. A Graphical User Interface (GUI) has been developed for visualization, segmentation and quantification of pathological features by the pathologists and the cytologists. Automatic Pipelining of the jobs over the Ethernet in an existing Distributed Medical Data Processing System has been successfully completed. There would be a single relational database for maintaining the intermediate images, output data and process log, etc. This work is done under the image Database Generation part to minimizes human interaction in the project.

(c) A project on Recognition, Segmentation and Quantification of the filamentous bacteria in industrial sludge has been successfully undertaken. The bacterial filaments are segmented from complicated volumetric images and used for quantitative evaluation. An attempt for qualitative evaluation of the filamentous bacteria based on morphology and other prior information will be taken up in the coming year.

Digital image and fuzzy geometry

(a) Many conventional geometrical definitions of Euclidean space do not work in digital space. For example, there is no unique definition of convexity in digital domain A new definition of digital convexity has been proposed recently and their properties are established. A corresponding definition of convex hull as well as circular hull in digital domain has also been proposed. Fuzzy geometry is a convenient tool for defining object shape properties. An approach of finding convex hull, starshapedness, elongatedness, compactness, etc. have been proposed. Also, a Hausdorff distance metric between fuzzy sets has been defined. Relational fuzzy properties between fuzzy objects have also been developed.

Computational Linguistics, Natural Language Processing and Speech Analysis

A. Bangla Spelling Error Pattern Analysis and Spell-Checker Design

(a) The aim of this project is to develop an appropriate error pattern found in texts written in Bangla, the second most popular language and script in the Indian sub continent. The study was made on graphemic as well as phonetic error found in handwritten as well as typographic data. For graphemic error, handwritten data were collected from different sources, while typographic data were collected from a corpus developed using PCs. For phonetic error, data were collected from dictational handwritings and dictational text typing. A total of 1,51,62,317 handwritten words and a total of 3,75,723 typographic words were collected and studied. Studies were made on two major levels of error, namely, word level error and sentence level errors. Non - word error and Graphemic shape error etc., are the types of errors belonging to the class of word level errors, while real word error like stylistic such as "Guru Chandali" errors, grammatical errors etc., run on and split word error and punctuation error belong to sentence level errors. The misspelled words were first sorted out from the raw data. They were further processed and categorized into different types of errors in different levels. Patterns of these types of errors were developed and listed in the form of tables.

(b) A novel technique of localization and correction of non-word error is described. In this technique a candidate string S of n characters is searched in the conventional dictionary Dc. If S is a non-word, its first k1 n characters will match with a word in Dc. (If k1 = n then the word in Dc must be longer than n). A reversed word dictionary Dr is also generated where the characters of the word are maintained in a reversed order. If the last k2 characters of S match with a word in Dr then, for single error, it is located within the intersection region of first k1 + 1 and last k2 + 1 characters of S. We observed that this region is very small compared to word length for most cases and the number of suggested correct words can be drastically reduced using this information. We have used our approach in correcting Bangla text, where the problem of inflection is cleverly tackled.

B. Machine Translation

Bilingual machine translation from Hindi to Bangla in the restricted domain of weather forecast has been considered. The approach is essentially one to one mapping of words and phrases from the source language to target language because both Hindi and Bangla sentences have similar syntactic structures. However, one to one mapping is not always possible because of word polysemy and some minor variations in syntactic structures of the two languages. Some rules have been used in the translation process to take care of them. The algorithm has been tested on one hundred sentences with satisfactory result in most of the cases.

C. Morpheme Parser

For NLP, an automatic morpheme parser for single Bangla verb form has been developed. It can work for both finite and non-finite verb forms. The machine automatically identifies a verb from a running text, breaks it into root and suffix part (if any), determines if any morpho-phonemic change has taken place within the surface form, identifies its morphological properties such as aspect (continuative), auxiliary, person, tense, particle markers etc., and finally supplies the meaning of it. Moreover, it provides all the possible valid parses with all relevant morphological information for a surface verb if it has the possibility of multiple parsing. This single verb parser is being used for

compound and reduplicated verb form analysis. The same methodology (with necessary modification) can be generalized for parsing other grammatical text categories such as Bangla nouns, adjectives and adverbs, etc., for which work is in progress.

D. Utterance Rule Generation for Speech Synthesis

For standard utterance of Bangla words an exhaustive set of rules is formed after thorough search on a large text corpus. In standard utterance of Bangla, the first and the last grapheme of a word is most important. Hence, our work has emphasized mostly on word-initial and word-final grapheme. But intermediate graphemes are not left unnoticed. Most of the rules for word-initial and word-final graphemes are applicable for intermediate graphemes also. However, exceptions are also mentioned with examples. Each rule is supported by percentage of occurrence found in the corpus with examples and exceptions. These rules are being implemented in the machine for synthetic speech so that it sounds more human-like rather than mechanical. The rules will also be useful for language learners.

Neural Network

(a) A neural network model to synthesize texture images has been proposed. The model is based on a continuous Hopfield-like network where each pixel of the image is occupied by a neuron that is eight-connected to its neighbours. A state of the neuron denotes a certain gray level of the corresponding pixel. The firing of the neuron changes its state, and hence the grey level of the corresponding pixel. Different two-tone and grey tone texture images can be synthesized by manipulating the connection weights and by varying the algorithm. A Markov chain principle has been employed to decide on the multiple state transition of a neuron. The model can be employed for texture propagation with the advantage that it allows propagation without showing any blocky effect.

(b) Using a multilayer perceptron (MLP), a texture segmentation algorithm has been developed. Here users can avoid selection and computation of the feature set and hence real-time segmentation may be possible. The technique apparently works in a fashion similar to our visual system whereby we do not consciously compute any feature for texture discrimination. A detailed study has been made for the selection of the network size. A newly proposed variant of the back-propagation algorithm has been used for more efficient training of the network. An edge-preserving noise-smoothing approach has been proposed to remove noise from the segmented image.

(c) Concepts of "activation level" and "activation region" have been introduced into a self-organizing neural network model for more accurate shape extraction. The new model is quite robust with respect to several types of noise and works for binary images, dot patterns and gray level images.

Advanced Computing & Microelectronics Unit

Research Activities

Heterogeneous Computing

During recent years, Heterogeneous Computing (HC) has become one of the thrust areas of research in the field of parallel processing. HC involves the use of different types of parallel processors, processing components or connectivity paradigms to maximize the overall system performance, cost effectiveness and development efforts.

The goal of heterogeneous computing is the high performance execution of a single complex application on a cluster of high performance systems with possibly dissimilar architectures. It is an important and emerging field drawing concepts from both parallel and distributed computing. Though the different components of HC have appeared in the scientific literature over the past few years, heterogeneous computing is still in its infancy. Heterogeneous computers promise cost effective compute cycles. But there are lot of issues yet to be studied in terms of efficient scheduling, ease of program development, performance evaluation and design of optimal HC environment for a specific application. Scientists and researchers from a variety of

disciplines have started participating in the development of heterogeneous applications using a currently available tool named Parallel Virtual Machines (PVM) and the associated job dispatchers. The objective of our proposed project consists of the following :

(a) We plan to develop a suitable model of computation for a heterogeneous computing environment involving a combination of dissimilar machines. Devising a suitable topology for interconnecting different component processing units is also planned to be studied. Appropriate methods of analysis will also be developed to predict the behaviour of such complex systems.

(b) Different application problems will be mapped on such an HC environment containing several (5-6) processing nodes having different architectures. The performance of the HC environment in executing different problems of varying size under different connection paradigms and different scheduling policies will be measured through actual experimentation. Then the experimental results may be compared with the theoretical estimations. The best possible computing environment for a given application can be identified from these experimental data. Typical applications include weather-forecasting, genetic engineering, etc.

Several theoretical results have been obtained on the efficient topology for interconnecting multiprocessor systems and also on designing parallel algorithms for solving different numerical and graph-theoretic problems.

Logic Synthesis and Design for Testability

Logic synthesis and design for testability techniques are indispensable in the VLSI circuit synthesis and testing. A typical VLSI chip may consist of hundreds of millions of transistors, design of which requires specialized design tools. To ensure high reliability, yield and maintainability, these chips must be tested during design, production, and while under operation. Unless the chips are designed with in-built easy testability scheme, testing will be a formidable task, if not impossible. In this project, our objective will be to innovate new design methodology for gate-level logic synthesis and redundancy elimination, targeted to having high fault coverage, in terms of stuck-at faults, as well as robustly testable delay faults.

The results obtained in this area during the period in question are given below :

(a) Logic synthesis with non-scan sequential circuits is of utmost importance in the recent trends of high performance circuit design. Investigations have been done on the redundancy problem in synchronous sequential circuits. Identification and elimination of redundancy have been studied, with a special emphasis on isomorph-redundancy. Several new attributes of such redundancies have been formulated, and their impact on logic synthesis has been studied.

(b) We have also developed a novel scheme of BIST (Built-in Self Test) technique for detecting stuck-open faults in combinational CMOS VLSI circuits. Efficient BIST design for universal testing of stuck-open faults was an open problem. The proposed scheme is not only robust but also universal. Its hardware overhead is low, and testing time is significantly reduced. In addition, a new technique called *adaptive* BIST has been developed. The scheme is useful for testing arbitrary CMOS complex cells, and the test sequence is independent of the circuit structure and its functionality.

Multi-Mesh Architecture

The Multi-Mesh (MM) architecture, built around 2-D meshes, has newly been proposed by us (Ref. Das and Sinha, Proc. 9th IPPS, pp. 17-21, April 25-28, 1995, Santa Barbara, and M. De, D. Das, M. Ghosh and B.P. Sinha, Proc. HiPC'95, pp. 707-712, held in New Delhi, India during Dec. 28-30, 1995). This architecture provides the following features :

(a) The number of processors is $N = n^4$, for some integer $n > 2$. The smallest systems can be built with 81 processors.

(b) Every processor will have a uniform degree of 4 only.

(c) Although the number of links is same as that of an Illiac IV architecture or a 2-D torus, the MM topology provides a diameter of 2n, i.e., $2N^{1/4}$ in contrast to $2N^{1/2}$ for an Illiac IV topology. This reduced diameter helps to implement the following algorithms very efficiently :

Summation/Average/Maximum/Minimum	: $O(N^{1/4})$ time
Matrix Transpose	: $O(N^{1/4})$ time
p x p matrix multiplication	: $O(p^{0.8})$ time (compare this with 0(p) time on a 2-D mesh)
p-point DFT computation	: $O(p^{0.8})$ time
Sorting :	
n^2 independent sets of n^2 elements each	$O(n)$ time
n independent sets of n^2 elements each	: $O(n)$ time
n^2 elements	$O(n)$ time
Lagranges interpolation on n^2 elements	: $O(n)$ time

(d) The 2-D mesh can also be emulated on this MM topology in constant time. Thus the 4-neighbour adjacency property can also be preserved in a certain sense on this topology.

(e) Point-to-Point communication, single node broadcast and multicast can all be implemented on this network in $O(n) = O(N^{1/4})$ time.

(f) Under single node or link failure, the diameter will not increase by more than 6. Other properties will be gracefully degraded with faults.

(g) Any existing algorithm on a 2-D mesh or torus can be easily transported to this new architecture and this is still a subject of further study and software development

Apparently, the proposed architecture will be able to efficiently implement a large class of algorithms in numerical applications, image processing and other real-life situations very efficiently without any additional hardware investment over that required for a 2-D mesh.

During the academic year in question, efficient algorithms for (i) multicast in $O(N)$ time, (ii) complete exchange using wormhole routing in $O(N^{1.5})$ time and also (iii) permutation routing on the Multi-Mesh have been developed. The sorting algorithm on the Multi-Mesh has also been further improved.

Electronic Design Automation

During the past 10 years, members of this Unit had done extensive research in the area of VLSI Design including synthesis, testing and physical design. New techniques of testable design, partitioning, floorplanning and routing in microchips have been developed. With the advent of high-performance VLSI and ULSI (Ultra Large - Scale Integration) chips, and MCM's (Multi-Chip Modules), efficient EDA tools targeted to achieve high speed and low power design are now in great demand. The research areas explored include the following

(a) Performance driven logic partitioning and floorplanning.

(b) Unified schemic for global and local routing

(c) Low power design of VLSI chips.

Efficient algorithms for high performance floorplan design and routing in VLSI Circuits have been proposed and tested on benchmarks. The results outperform earlier methods both in cost of chip fabrication and turnaround time. In particular, we have addressed (i) the optimal linear placement problem of circuit graph to minimize signal delay, (ii) floorplan-area optimization for custom designed microchips, and (iii) partitioning for improved wire routing based on geometric measures

Applications of Computational Geometry to VLSI Layout

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 defense, robotics, database, and pattern recognition.

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. A novel routing-driven partitioning scheme has been formulated.

Mobile Computing

Mobile computing refers to the use of portable computers interconnected through wireless networking. It allows the mobile users to effect versatile communication with other people along with continuous access to the services and resources of the land-based computer network. Designing software for a mobile computing system is different from that involved in case of a stationary networked system in certain aspects, as mobility induces several new problems.

Wireless communication used for mobile computing system is characterized by low bandwidth channels with high error rates and more frequent disconnections. These factors can increase the communication latency resulting from the requirement of retransmission of data packets arising due to error control protocol and short temporary disconnections. Mobility, in turn, causes wireless connections to be sometimes lost or degraded due to signal weakening, when the users travel beyond the coverage of network transceivers or enter areas of high interference. Also, the number of devices in a network cell varies dynamically and a large concentration of mobile users at a single place like conventions, may also overload the network capacity.

A mobile computer's net-address changes dynamically. This dynamic feature in mobile wireless networks leads to a problem of keeping track of the topology connectivity. This problem, also known as the location management problem, becomes too complex when the rate of change is high and the network size is large. Thus, an important issue in mobile computation is the design and analysis of the topology management schemes.

New routing schemes are also needed for such mobile networks. Conventional routing protocols are not applicable for networks where the topology connectivity is subject to frequent unpredictable changes. A suitable loop-free routing is desirable for this purpose, since a loop-free routing will minimize the consumption of resources during communication and also the communication delay involved in the process. Routing schemes also need to be developed to tolerate corrupt wireless links.

In a mobile computing environment, all the neighboring base stations are connected to a Mobile Switching Centre or MSC. When a mobile user is about to leave a cell, the cell's base station transfers the ownership of the cell to another base station getting the strongest signal from the mobile user. If a call was in progress at this point of time, then this call should be switched to a new channel (as the old one is not used in any adjacent cell). This new channel assignment is basically done through a switching network.

We have developed a generalized shuffle exchange network, which can be used as an efficient MSC, even when the number of base stations is not necessarily a power of 2. The network offers a very cost-effective as well as fast switching technique for *hand-off* procedure between base stations. The routing algorithm and the fault-tolerance of these networks are currently under study.

Microelectronic System Design using FPGA's

Field-Programmable-Gate-Arrays (FPGA's) are now being extensively used to synthesize complex logic circuits in the laboratory. These IC chips have been following features : (i) high degree of complexity (thousands of gates), (ii) complete programmability to implement arbitrary architectures, (iii) programmability in the laboratory and (iv) a large number of contact pins. In this project, we have two objectives in mind :

An exposure to FPGA's has now become indispensable in a 'VLSI Design' course. FPGA devices can be configured in hours rather than weeks or months. The logic devices as well as routing patterns are pre-fabricated on the chip. Synthesis of an arbitrary architecture can be made by proper logic design followed by programming the FPGA to implement the circuit and routing. This needs

(a) A hardware platform with FPGA logic card,

(b) Design software,

(c) FPGA chips which are to be programmed.

Assignments of moderate complexity can be completed within one course. The feasibility of rapid prototyping of systems would encourage the students to undertake more experimental research on realistic problems of larger size.

Optimal logic synthesis and routing targeted for FPGA realization has become an upcoming area of research. In particular, we shall undertake the investigation on logic - partitioning problem in an FPGA environment. Given a complex circuit in terms of interconnection of modules, the problem is to partition it into smaller sub-complexes, such that the overall design and routing on FPGA become optimized.

Synthesis of fault-tolerant systolic arrays with FPGA architectures is being studied. We have also developed a new technique for synthesis of large synchronous sequential machine. The proposed design has less hardware overhead, shorter test application time, and a very high fault coverage. The design can easily mapped to a FPGA-based architecture.

Discrete Event Simulation

Synthesis of very large sequential machine now forms an integral part of high performance ASIC VLSI chips. Typically, such 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, (iv) layout simulation.

If any design error is identified during simulation, it is corrected and the process is iterated. Discrete event simulation is also 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 being studied in a UNIX environment run on a Silicon Graphics Workstation. Logic simulation at switch-level is being studied on a PC platform.

Large scale simulation studies have been made in the earlier years to assess the performance of a (64 x 64) baseline switching network with output buffering. It has been observed that the output rate was varied from 20% to 100% whereas, the number of buffers in a queue within a switch was varied from 1 to 12

Electronics and Communication Sciences Unit

Research Activities

Theoretical and experimental investigations are being carried out in the following areas.

A. Computer Vision, Biomedical Imaging and Image Analysis, Artificial Intelligence, Approximate Reasoning and Neuro-Fuzzy Computing.

Mathematical Morphology

Mathematical morphological tools/frameworks for image processing and analysis are extensively studied Fast algorithm for generating pattern spectrum in hexagonal grid using hone-comb distance transform is proposed The proposed morphological multi-scale edge detector is compared both quantitatively and qualitatively with other well known edge detectors and is found to be superior in overall.

Document image analysis

Document image is analyzed and segmented into homogeneous rectangular blocks of unique entities as text half-tone pictures, graphics or line drawing, headings and tables Before segmentation, document page image is deskewed i.e., the page image is aligned vertically Mathematical morphological operators are used to develop fast algorithms to the said job. Results of the developed algorithms are compared with that of existing methods.

Multisource data integration

For the better interpretation of the object/scene that has been imaged, integration of multisource data having various spectral and spatial resolutions is being carried out from the combined information Preprocessing techniques, in this work, include classification of various regions based on higher spectral resolution data and extraction of linear features from higher spatial resolution data using multiscale operator The techniques are applied on biomedical images as well as remote sensing data

Analysis of 3D objects

A new method to estimate robustness of a shape preserving parallel thinning algorithm under random noise and rotation has been introduced. Topology based segmentation method for 3D objects devised and tested for its capability of handling noisy objects. Local topological parameters of 3D objects were studied and reported

Geometric invariance in Symmetrical object

Application of geometric invariance in computer vision includes detection of symmetric contour pairs under non-fronto-parallel viewing condition This is followed by determination of symmetry line images subjected to projected object onto image transformation. This is evaluated from the inter-contour reflection matrix

Neuro-fuzzy computation

A fusion methodology (between fuzzy logic and neural net) has been developed and tested for recognition of vowels and occluded object

Qualitative physics

Extension of the qualitative simulation (QSIM) algorithm has been made with qualitative curvature The basic purpose of qualitative physics is to describe the behaviour of the complex dynamical system in qualitative manner instead of quantitative differential equation

B. Remote sensing and data analysis in atmosphere science and wave propagation

Analysis of satellite data

A comprehensive algorithm for classifying convective clouds in satellite images has been developed. and tested on INSAT data. The objective is to track cloud clusters in a sequence of satellite images and along with the cloud classification it will provide cloud motion vectors (CMV) The CMV determination using correlation technique in half hourly INSAT image triplet is routinely performed by India Meteorological Department (IMD) and classification based techniques could supplement this process in terms of improvement in quality and quantity of CMV's. The outline of this algorithm is already presented before Space Application Centre (SAC), ISRO scientists in RESPOND (ISRO) seminar series that leads to funding of research in this line by ISRO

A study of convective clouds and their classification based on temperature profile from satellite (IR-band) imageries was conducted and a bivariate normal distribution was considered as model for convective clouds during the tropical disturbances The work has been reported in IEE Trans and is under review

Analysis of SODAR images

Patterns of ABL (Atmospheric Boundary Layer) shapes have been extracted from SODAR images A rule based algorithm for network driven inferencing mechanism has been developed and successfully tested on recognition of SODAR patterns An algorithm for image segmentation based on Fuzzy c-means has also been implemented for SODAR image

Modelling of transport phenomena in ABL

To understand the dynamics of the Planetary Boundary Layer (PBL), study of transport phenomenon in the PBL is being simultaneously carried out for developing a suitable model for transport of scalar in the PBL. Validity of the model was continuously checked with the help of 30m meteorological tower data The main aim of the project was to develop a turbulent transport model for the monsoon period, substantial part of which has been carried out Analysis of the sodar and tower data available at different stations in India continued with a view to deriving some deeper understanding of PBL dynamics

Fractal algorithm for study of ABL dynamics

Some studies have been conducted on the applicability of modern technique of fractal and multifractal in the dynamics of atmosphere and environment The fractal nature of semidiurnal variation of radio refractivity index has been studied and reported in IJRSP, India Applicability of fractal decomposition of sodar image technique to study thermal convection in the planetary boundary layer has been studied and the result was published in a journal

C. Acoustic phonetic studies on Indian speech and musical sounds leading to automated speech recognition

Acoustic Phonetic Study

Acoustic phonetics studies of Assamese vowels and plosive consonants have been reported. Spectrographic analysis of 330 Oriya words spoken by four male informants are continuing to study the acoustic phonetic features. These will provide reliable data for computer recognition and synthesis of speech for these languages as well as assistance to the effort in standardization of phonetic quality of educational and cultural use of voice media.

Perception study

For automatic computer processing of speech it is necessary to have comprehensive knowledge about acoustic correlates of stress and the perceptual significance of these. With this view, the perception experiment of continuous speech for Bengali language is conducted for 10 minutes long radio news broadcasting in standard Bengali by a female news reader. The analysis of text reading indicates that standard Bengali is a language with bound stress, the stress being at the first syllable and clearly exhibits augmented-articulatory-effort to be essential as in spoken language processing (SLP) suprasegmentals, particularly stress plays a very important role. Furthermore in languages having bound stress this may help in word boundary detection.

Neuro-fuzzy speech recognition

Neuro-fuzzy system has been developed for recognition of Bengali and Assamese vowels and about 80% recognition score is achieved. In next phase speaker independent word recognition using neuro-fuzzy classification technique will be developed. All these systems will be used for man-machine communication in context of Indian languages.

Identification of musical ragas

The analysis of 'shruti' positions in Indian classical music is very important for identification of different gharanas. Records of actual performance of several maestros on raga Iman have been analyzed, and different shruti positions have been extracted. The shruti positions have to be extracted for other important ragas of Indian classical music and being carried out in collaboration with Sangeet Research Academy, Calcutta

Machine Intelligence Unit

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

The investigation that is currently being done in MIU comprises both the development of these technologies individually and in an integrated (hybridization) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, image processing, brain modelling, expert system, vision, control etc., related to the design of intelligent systems. Hybridization such as neuro-fuzzy, neuro-rough, neuro-fuzzy-genetic helps in making such systems artificially more intelligent.

Note that these tools are collectively known as soft computing paradigm. They provide the theory of flexible information processing, which can deal with real life ambiguous situations in an efficient manner like human beings, and therefore form the basis of future generation computing systems.

Research Activities

Pattern Recognition

Genetic algorithms (GAs) have been applied for pattern classification in N-dimensional feature space, where a fixed number of hyperplanes is used for modelling the decision boundaries of the classes. It has been proved that as the size of the training data tends to infinity, the error rate of the GA-based classifier approaches the error probability of Bayes classifier. The number of hyperplanes required for modelling the class boundaries has also been adaptively evolved from the GA itself utilizing 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 $\Re^N$ have also been studied. The utility of GA based classifier in classifying the pixels of SPOT images representing some parts of India has been demonstrated. In another investigation, an effect of chromosome differentiation for performing restricted cross-over operation is studied. This helps in accelerating convergence of the GA process. An analogy of the GA classification with MLP is determined. Based on this, an algorithm for optimum network generation is formulated.

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 for SPOT images. Under an externally funded project, a software package has been developed on this and handed over to defense 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 along with 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. A concept of *fuzzy* α-*hull* is also proposed. A new minimal spanning tree based clustering algorithm has been proposed and its relationship with Bayes classifier has been theoretically found.

A new model for *fuzzy-possibilistic* clustering has been proposed. Unlike existing models, the proposed mixed model can provide us with both fuzzy *membership* values and *typicality* (possibility) values, and consequently can give a much better understanding of the substructures present in a data set. Dempster-Shafer theory of evidence has been used to integrate feature-wise rank information to design classifiers.

Electroencephalogram (EEG) reflects the electrical activity of the brain in the various states of sleep and wakefulness. One of the methods for quantifying (qEEC) such activity is calculating the FFT (Fast Fourier Transform) of the EEG waves. Under different conditions of stress and exercise, the qEEC 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 of 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.

The effectiveness of fuzzy geometrical features has been demonstrated for classifying distorted overlapping fingerprints directly from raw unprocessed images. The output is defined here in terms of six classes *viz.*, Left-loop, Right-loop, Twin-loop, Plainarch, Whorl and Overlapping. Overlapping (between any two of the above five pure classes) in various degrees and orientations is artificially produced on pure fingerprint images. Distorted patterns are generated for all the six classes, with random noise, cut marks and information loss in certain random locations. The fuzzy geometrical features are found to be the best for

classifying these patterns when Bayes', k-NN (with k = 1, 3, 5) and MLP (multi-layer perceptron) classifiers are used.

An intelligent decision making system for obstacle avoidance by a mobile robot has been developed. The task of incorporating audio and visual capability is in progress.

Image Analysis/Processing and Computer Vision

Efficient smoothing algorithm using isotropic and anisotropic diffusion processes, and coding algorithms using a modified Bezier-Bernstein approximation technique have been developed. Based on the second generation coding technique, two different algorithms have been developed which are seen to yield high compression ratio. A new contour coding scheme, based on the properties of discrete circle, has also been developed. The algorithm is seen to yield high compression ratio for a class of binary images. Various fractal and wavelet methods for image data compression are under investigation.

An edge detection problem using automatic thresholding scheme is under investigation. The multiresolution aspect of wavelet analysis is used to authenticate the edge locations. A new method of edge detection using the concept of multiresolution and mathematical morphology is developed. The new method is found to have better noise immunity and positional accuracy compared to other existing morphological techniques.

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.

A new gray scale based Hough transform algorithm has been proposed for finding line segments in gray level images. This algorithm has been found to be useful in extracting regions in graylevel images, especially for satellite images.

Artificial Neural Networks

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are proposed. Net work model 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. 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 studied for thinning in graylevel images. Some efficient algorithms based on cellular neural networks have also been developed for object extraction problem.

Dimensionality reduction using different neural networks has been done. Selection of an optimal feature set for pattern recognition problems has been realized. Several algorithms for automatic selection of an optimal/near optimal architecture for an MLP have been developed. An MLP based approach for determining the shape of a pattern class from its sampled points is proposed.

Feasibility of using connectionist models for implicit identification of the highly interactioning relations between various ingredients of composite materials has been investigated. The effectiveness of connectionist models for absorption/desorption of hydrogen storage materials has been demonstrated. Such methods can drastically reduce the time and cost R & D in material science, tyre industries, medicine, etc.

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.

A new learning algorithm is designed for blind separation of uniformly distributed source signals. For uniformly distributed sources the Fisher information matrix diverges, and under such circumstances the Cramer-Rao bound is not applicable. It is possible to design new algorithms for such special cases which exhibit superefficiency of $O(1/T^2)$ convergence. The design of the new learning algorithm is an attempt in that direction.

Genetic Algorithms (GAs) and Fractals

Here the investigation involves both theoretical development of GAs and its different applications to pattern recognition problems.

Convergence of GAs with elitism is proved. Attempts are also being made to find the optimal stopping time for GAs.

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

A concept of "age of individuals" so as to decide the 'parenthood' of them is introduced; and this is seen to maintain more diversity in the population. Middle-aged individuals are considered to be more fit to produce offspring. In another work, parents' fitness is used as a part to decide the fitness of individuals thereby giving more importance to individuals coming from 'better families'. This gives more directionality towards the goal. GAs are made efficient also by introducing better individual in terms of fitness function from outside the population or preserving and reintroducing individuals which were dropped out at earlier generations. This promises to increase the general degree of exploration of the search space, thereby improving the performance. A few strategies are developed to select mating pairs for the crossover operation. A study on the utility of the multi-parent crossover (in contrast to two parent crossover) is also made.

A concept of search space division by employing a multi population scheme is introduced in GAs. In this scheme a GA divides the whole search space into sub spaces depending on the convergence status of the population and the solutions obtained so far. The scheme helps to prevent premature convergence to local optimal for multi-modal problems. It is shown that for a bi-population real coded GA the scheme can provide local searching capability to genetic search.

A methodology for searching robust solutions (in contrast to the best one) by GAs is developed. The scheme employs addition of noise with the search space parameters, before evaluating the fitness of individuals. The scheme detects stable solutions in contrast to sharp ones and this helps in real life design problems where solutions are expected to be unaltered with small variation of parameters.

An application of GAs for automatic 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 GA based model to evolve Hopfield type optimum network architectures for object extraction has been developed. The performance of GAs vis-a-vis simulated annealing for optimization is investigated.

A method has been developed for magnification of digital images using iterated function system (IFS) with the help of GAs. GAs have helped in reducing the search space for finding near optimal transformations for coding. These codes are directly used for image magnification instead of the original images and thus reducing the memory requirements as well as computing time. Further, a mathematical analysis of the reconstructed images using IFS codes has also been carried out. Attempts are being made to develop an edge detection algorithm using fractal codes and to develop a GA based photocopying algorithm of fractal image compression for better compression ratios. IFS and GA based EEG signal compression has been

successfully implemented. Moreover, the attempts are being made to retrieve the class specific features of EEG signals from IFS codes.

A method has been developed for fitting straight lines to data sets using GAs. The method is found to possess nice theoretical properties and, experimentally, it is found to provide acceptable results. It is found to provide better results than the spline based methods for straight line fitting. The problem of outliers has been tackled effectively with that method.

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 connectionist expert system for rule generation and inferencing has been made along with applications to real life data. This shows how pattern description in terms of linguistic properties and membership values can be processed by a neural net for fuzzy and crisp classification, and their merits over conventional networks and Bayes' classifier. Utility of such architectures for generating non-convex decision regions is also demonstrated. A generalized framework for integration of multilayer perceptron and fuzziness measures has been developed to design an unsupervised system for object extraction. Implementation of fuzzy set theoretic operators using neural networks and the utility of these networks in pattern classification and rule generation have been demonstrated.

A neural network realization of fuzzy inferencing has been developed. The proposed scheme propagates the similarity/dissimilarity between antecedent and the facts to the inferred conclusion and thereby reduces some of the problems of original compositional rule of inference. Some investigation has also been done to obtain a neural realization fuzzy relation for inferencing with a view to getting better inferencing and obtained encouraging results.

Various ways of integrating fuzzy set theory and connectionist system for feature evaluation have been formulated. The performance of the system has been theoretically analyzed. Currently, attempts are being made to develop a neuro-fuzzy system with unsupervised learning for both feature selection and extraction. These neuro-fuzzy systems have been applied to various real-life data sets. In addition, the neuro-fuzzy system for feature extraction under unsupervised mode of training, has been applied to IRS images to determine new spectral band(s) which is (are) more informative than the original ones.

An attempt has been made for building a case-based pattern recognition system using fuzzy sets and neural networks. *Cases* are typically labelled patterns which represent different regions or characteristics of the classes. Incorporation of fuzzy set theory helps in selecting the *cases* from ambiguous/overlapping regions. The methodology is realized in a connectionist framework where the architecture is determined through growing and pruning of nodes, under supervised mode of training, on the basis of fuzzy similarity between patterns.

One important project in this area entitled "Neuro-fuzzy expert system : design and implementation has been successfully completed under the Jawaharlal Nehru Fellowship scheme. This project was fully funded by the Jawaharlal Nehru Memorial Fund as part of the Fellowship award.

Brain Modeling

The human brain is a much superior information processing machine compared to any artificial device constructed so far. This has led scientists to study in detail the different processes involved in biological neural computation and to incorporate the facts so gleaned into more realistic models of brain function. This enterprise, known as "brain modeling", aims to create artificial entities, more "intelligent" compared to present-day systems in performing cognitive tasks.

Work has been carried out in networks of excitatory-inhibitory neural pairs with piecewise linear activation function. Even simple networks have been seen to exhibit a complex range of behavior, including

super-stable periodic orbits and chaos. Analytical calculations and computer simulations have been features like border-collision bifurcation and riddled basins of attraction of the system. The network behaviour has also been studied using sigmoidal activation functions.

The phenomenon of state synchronization among elements of a coupled chaotic network has been studied. A system of three chaotic elements was coupled with each other, such that they competed with each other in phase-synchronizing the network. This work is pertinent in discovering the neural basis of "attention".

Stochastic Resonance (SR) is a nonlinear phenomena, where noise plays a constructive role by enhancing subthreshold signals. As the output of deterministic chaotic process is often indistinguishable from noise, a study on whether chaos can give rise to SR-like behavior was carried out. Using a piecewise linear chaotic map, periodic perturbations were given in both multiplicative and additive sense. Analytical calculations, supplemented by computer simulations, showed that in all cases the response of the system is enhanced at the signal frequency. This points to the utility of chaos in neural networks for amplifying weak stimulus. At present, a simple neural network model showing this phenomenon is being studied in detail.

Work has also been carried out on the application of network of excitatory-inhibitory neural pairs for low-level vision. Motivated by the neural architecture of the retina, three layers of such pairs have been connected via appropriate weights. Edge-detection and segmentation of gray-level images by processing through these layers have been studied.

Rough Sets, Logic and Applications

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 semantic 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.

An attempt has been made to integrate rough sets and fuzzy neural networks for designing a knowledge-based system. Rough set-theoretic techniques are utilized for extracting crude domain knowledge that is encoded among the connection weights. Methods are derived to model (i) convex decision regions with single object representatives, and (ii) arbitrary decision regions with multiple object representatives. A three-layered fuzzy MLP is considered. The feature space gives us the condition attributes and the output classes the decision attributes, so as to result in a decision table. This table, however, may be transformed, keeping the complexity of the network to be constructed in mind. Rules are then generated from the (transformed) table by computing relative reducts. The dependency factors of these rules are encoded as the initial connection weights of the fuzzy MLP. The network is next trained to refine its weight values. It may be noted that the optimal number of hidden nodes is automatically determined. The classification performance is found to be better than the conventional and fuzzy versions of the MLP. The model is capable of handling input in numerical, linguistic and set forms, and can tackle uncertainty due to overlapping classes.

Fuzzy Logic, Uncertainty Analysis and Control

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.

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 reasoning model that can account for incorrect and inconsistent rules obtained from human experts or otherwise has been proposed. The extended model has been used not only for handling inconsistent rules but also for selection of rules for a fuzzy controller. The extended model can be used in any other non-control rule based systems including pattern recognition. Algorithms have been developed for realizing self-tuning PI and PD type fuzzy controllers through on-line of output scaling factors. The on-line gain updating factor is computed using a rule-base defined on error and change of error. The striking feature of the scheme is that it is model independent and works excellent even with the most natural and unbiased membership functions (equispaced symmetric triangle with 50% overlap with neighbours) for all linguistic values. Self-tuning controllers have also been designed through online adjustment of the input as well as simultaneous update of both input and output scaling factors. Genetic algorithms have been used to design self-organizing fuzzy controllers. A fuzzy neural network has also been used for rule selection. A general purpose neuro-fuzzy tool for realizing fuzzy reasoning with more intuitively plausible properties has been developed. Exploratory data analysis is used to design system for direct extraction of rules from numerical data. The proposed scheme clusters the input data and output data separately and establishes correspondence between the clusters found in the two domains and finally translates the results into rules. Methods for estimating various parameters of the rule-base are also suggested.

Fuzzy control paradigm has been used to design systems for structure preserving dimensionality reduction. Unlike Sammon's method such a system has good predictability and can handle large data sets. The schemes are found to outperform the existing neural implementations of Sammon's method both in terms of quality of output as well as computation time.

International Collaboration

The Institute has an international collaborative project with the College of Engineering, Osaka Prefecture University, Osaka, Japan-which was initiated and is being coordinated by MIU. Members of MIU are also involved as co-investigators in the INDO-POLISH collaborative project title "Reasoning under uncertainty about complex objects/rough set theory and fuzzy set theory". This is coordinated by the Dept. of Science & Technology (DST), India and the Polish State Committee for Scientific Research (KBN), Poland.

Physics and Earth Sciences Division

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

Geological Studies Unit

Research Activities

The broad areas of research activities that were carried out in the Geological Studies Unit (GSU) between April 1997 and March 1998 may be grouped under four heads - (a) Precambrian, (b) Gondwana, (c) Quantitative Geology/Computer Application, and (d) Colloid and Surface Science and Environmental Pollution in relation to Soil and Ground Water. In all 17 ongoing and 4 new projects were involved; one of the new projects was externally (DST) funded.

(A) The Precambrian research in the GSU strives at the understanding of the crustal development in the southeastern part of the Indian peninsula, integrating tectonic, stratigraphic, sedimentologic, structural, magnetic and metamorphic studies in the Pranhita-Godavari Valley, the Chattisgarh and Cuddapah basins, and the Sonakhan granite-greenstone belt and the Eastern Ghats.

(B) The Gondwana research basically involves the integration of the studies that are being carried out on the stratigraphic, palaeontologic, climatic and sedimentologic aspects with an aim to reconstruct the history of the Gondawana succession in the Pranhita-Godavari Valley, Damodar Valley and Satpura Basin.

(C) In the research of Quantitative Geology/Computer Application, empirical-statistical analyses of naturally arising field and laboratory data provide ways to build or evaluate quantitative models of significance in geological problems. Computer applications are done in- automation of various techniques commonly employed by the earth scientists.

(D) The research on Colloid and Surface Science continues since it has a good potential for its application to the studies of environmental science in the national context. In the research of Environmental Pollution in relation to Soil and Ground Water (geochemical/physicochemical aspects), it has been noted that in the last three decades, protection of the environmental compartments of water, soil and air all over the world has become a topic of growing importance and concern. There are, however, some important differences in the advances in obtaining clean soil and water in comparison with the goal of obtaining unpolluted air. The research has just been taken up.

A. Precambrian

(a) Pranhita-Godavari Valley

The studies on the evolution of the Penganga Carbonate platform have been completed and a Ph.D. degree has been awarded to Sri Joydip Mukhopadhyay, a collaborating scientist. Large number of debris flow limeclast conglomerates and calcarenite turbidites were identified in the distal part of the Penganga limestone sequence and existence of a major carbonate slope was inferred.

A laterally persistent bedded chert, which developed at the base of the slope was studied petrographically, and it has been inferred that the maturation pathway of the chert is similar to that of biogenic bedded cherts of the Phanerozoic. The bedded chert developed at very shallow burial depth, and can be used as a stratigraphic marker horizon in regional correlation. The origin of the bedded chert is now being looked into, and the role of Proterozoic organisms as well as of cold water oceanic upwelling on precipitation of silica is being evaluated.

A manuscript "Fabric Development in Proterozoic Bedded Chert, Penganga Group, Adilabad, India : Sedimentologic Implication" has been submitted to the Journal of Sedimentary Research, and is in revision stage.

Mapping of the thrust sheets within the Penganga Group identified in last several years was extended in areas NW of Adilabad during February, 1998. A large fault related fold has been identified and mapped. The structural elements collectively indicate that the Penganga Group in the northern part of the P.G. Valley evolved into a fold-thrust belt under a broadly NNE-SSW directed regional compression. Analysis clearly contradicts the long standing idea of tectonically passive character of the northern part of the Pengaga basin with a mobile belt situated to north or north-east of Adilabad.

Extensive occurrence of authigenic Fe-illite has been identified in a deep marine siliciclastic fan sequence incised within an on-slope limestone succession of the Pengaga Group. Our analysis suggests that the mineral is crystallochemically intermediate between glauconite and illite, and its formation is controlled more by the microenvironment than by the macroenvironment. This appears to be the first report of marine Fe-illite, and clearly contradicts the environmental significance that has so far been attributed to Fe-illite or glauconite. The analysis of chemical data from glauconite, Fe-illite and illite in different Proterozoic formations in the P.G. Valley shows strong linear correlation between several cations pointing to chemical substitution and transformation of one phase to another and possible existence of a chemical series from illite to glauconite through Fe-illite.

Bar-pool couplets have been recognised within the fluvial succession of Mancheral Quartzite, Sullavai Group. On the basis of the bar-pool sequences a new model for shallow braid bar deposition has been developed. This model differs from existing bar models and is more compatible with the process-based

approach developed from the study of modern rivers and scaled laboratory models. A paper has been communicated.

(b) Chattisgarh Basin

Stratigraphic and sedimentological analysis of the Chattisgarh succession in the southeastern and eastern part of the basin has been completed. An alluvial fan-fluvial to shallow marine transition has been established in south-eastern part around Panduka Group. A paper on the stratigraphy of the Chandrapur Group has been published by Sri Basudeb Dutta. Analysis of paleo-current data suggests easterly and southeasterly paleoslope.

A thick fan delta complex with mixed carbonate-siliciclastic in the outermost shelf and slope has been identified in the eastern part of the basin. It has been inferred that the basin, like the Penganga basin, opens up towards north, with a major northerly slope characterized by abundant sediment gravity flow beds and pyroclastics including welded tuffs, in the basinal part. Signatures of intrabasinal volcanism and development of fan delta point to an unstable basin condition and militate against the concept of tectonically stable Chattisgarh basin.

(c) The Eastern Ghats

It has been demonstrated through forward modelling that granulite facies metamorphism and partial melting in deep crust is possible without mantle involvement in any form. The models using time-dependent heat transfer solutions provide realistic constraints on the time-scales and length-scales of orogeny, particularly for collisional orogeny.

Dehydration melting under granulite facies conditions has been documented from several granulite belts - Kabaldurga in Karnataka, Chilka Lake area and Jenapora - Bhuban area in Orissa. Granulite-granite connection has been petrologically documented and isotopically dated as an Archaean event in the Eastern Ghats belt. New evidence of reworking in different granulite belts has been documented.

(d) Cuddapah Basin

The details of structure and stratigraphy in some key sectors of the Nallamalai Fold Belt (NFB) in parts of south India have been analysed to understand the kinematics of deformation in the NFB and adjoining parts of the Proterozoic intracratonic Cuddapah basin. The involvement of the basement in the cover deformation has also been investigated. Data obtained from S.R. Puram and Vellatur areas along the eastern margin of the NFB, from around Giddalur in the centre-west and from those around Cuddapah, Vontimitta and Rajampet have been interpreted in terms of an overall non-coaxial deformation with west vergine folds and thrusts. LPS strain indiated by development of slaty or spaced cleavage in argillaceous or other types of rocks accounts for a part of shortening across the belt as much in the western half of the NFB as in the eastern margin. However, higher LPS strain and refolded structures are recorded from the eastern margin. The granitoid basement is overthrust along the eastern margin only (Vellatur area). The smaller granite bodies of Vellatur and Ipur are post-tectonic with respect to main deformation in the NFB.

A structural map covering c.600 square Km in the southern NFB has been prepared. An area of about 200 square Km around Vellatur in the eastern margin has also been mapped to decipher the details of structures in the cover succession, basement-cover relation and emplacement of the Vellatur granite body. Preliminary fabric and microstructural studies show 'top-to-west' shear not only in the eastern margin but also in other subsidiary thrust zones internal to the cover sequence.

B. Gondwana Research

(a) Pranhita-Godavari Valley

Study of the osteology and paleobiology including mastication, hearing and taphonomy of the endothiodonts from a dicynodont complex from the Late Permian horizon of the Pranhita-Godavari valley has been completed. This late Permian horizon has been designated as Kundaram Formation. On the basis of the

fossil contents, this horizon is correlated with the *Trophidostoma* and/or *Cistecephalus* Assemblage zone of the lower Beaufort Group South Africa. Two *Endothiodon* species are established, of which one is a new taxon. The other one *Endothiodon uniseries* is studied for the first time in India. This entire work is submitted as a Ph.D. thesis titled "Endothiodont Dicynodonts from the Lower Gondwanas of the Pranhita-Godavari valley, Deccan India" to the University of Calcutta on December 1997. Study of the other Late Permian dicynodonts is being continued.

(b) Satpura Basin

A new faunal assemblage consisting of a dipnoan fish, temnospondyl amphibians, rhynchosaurs, dicynodonts and archosaurs has been discovered from the Denwa Formation. Two new species of capitosaurids have been described from this horizon. Besides some archosaur remains have also been collected from the overlying Bagra Formation.

A fossiliferous area of the Denwa Formation (at the central part of the Satpura Basin) has been mapped in detail. Lithologs are prepared particularly from the areas close to the upper boundary of the Formation. A graveyard of capitosaurid amphibians is discovered from the upper part of the Denwa Formation. The locality has yielded some complete skulls with many post cranial elements and the study of the taphonomy of these fossils is now in progress.

A study of sedimentology of the Denwa and the Bagra Formations of the Satpura Gondwana basin of central India was carried out which included the study of the palaeosols with an aim to reconstruct the Mesozoic palaeoclimate. Extensive field investigations were carried out in the Chindwara and Hoshangabad districts of M.P. to identify key lithological sections of the Denwa and Bagra Formations, characterize the different sedimentary facies, and collect palaeocurrent data and rock samples for analysis. A geological map on a scale of 1:50,000 of the study area had been under construction and orientation analysis of the palaeocurrent data was under progress.

A stretch of Bijori-Pachmari contact has been mapped around Nandia in Madhya Pradesh. The contact appears sharp but conformable. Preliminary investigation of the Pachmari Formation indicates the presence of a hierarchy of internal bounding surfaces within the fluvial sandstone. The bounding surfaces are significant in terms of architectural element analysis of the sequence.

Climate controlled change in the depositional environment seems to best explain the changing stratigraphic architecture of Barakar and Motur Formations. Detail petrofacies investigations indicate that provenance and tectonic regime remained unchanged during this period.

(c) K-T Boundary Extinction

An excavation was carried out at Balasinor, 100 Km. east of Ahmedabad, Gujarat, to determine the various kinds of dinosaurs that were buried together and the cause of their sudden death. The area excavated was about 35 meter by 10 meter, and it exposed more than 200 dinosaur bones. It was noticed that both carnivorous and herbivorous dinosaurs, young and adults, perished together in a catastrophic flood millions of years ago. An almost complete skeleton of abelisaur, two different kinds of titanosaurs and an ankylosaur were recovered. The dinosaur remains show striking similarities with those from other Gondwana continents, especially South America and Madagascar. It is now known that the isolation between northern and southern continents produced dramatically different evolutionary pathways among dinosaurs. The Indian dinosaur remains may provide important clues to their migration routes, their relationships with other Gondwana dinosaurs, as well as the past position of India about 65 million years ago, before the rise of the mighty Himalayas.

C. Quantitative Geology/Computer Applications

Systematic microstructural investigation of naturally deformed Q-F rocks and related theoretical investigation was undertaken with the following objectives - (a) assessment of the strain sensitivity of strain partitioning between phases and deformation mechanisms, and (b) to find out how varied feldspar content effects the development of quartz CPO in Q-F rocks.

Based on analysis of microstructures in naturally deformed rocks it has been found that a brittle-ductile toggle controls aggregate flow behaviour in natural progressive deformation of arkoses, feldspathic sandstones and grits under low grade metamorphism (Saha, 1995). An aggregate flow law for combined diffusion and dislocation creep in polymineralic rocks has been derived considering the volume fraction of the constituent phases affected by different deformation mechanisms (Saha, 1997).

Studies on samples collected from the Singhbhum mobile belt south of Tatanagar show an association of crystal plastic and pressure solution mechanisms plus some degree of microcracking (particularly in feldspar), in Q-F rocks containing significant muscovite (recrystallized argillaceous component or break down product of feldspar). In muscovite poor systems, crystal plastic mechanisms predominate. Microstructural and fabric data representing deformation in a relatively higher temperature domain are being studied from samples of granitoid rocks belonging to the Sonakhan granite-greenstone belt and collected from around Pithora, M.P. and those of the Vellatur area along the eastern margin of the Cuddapah basin. Meso-and micro-structures indicative of flow in magmatic to subsolidus state have been observed from the latter set of sample.

A research in the development of a computer simulation of natural water flow, erosion and sedimentation was in progress.

Aparent aperiodicity in fold development in Banded Iron formation has been simulated by superposition of different harmonics. Also the highly contrasting rheology of quartzite-hematite multi-layers not displaying large wave length folds has been modelled as bulk-homogeneous shortening and localized folding. This implies a transient but homogeneous material response during fold development.

Cephalometric studies of a group of Triassic amphibians is being carried out. This has helped in recognizing Indian metoposaurid amphibians as a separate taxon. Numerical analysis of the changes noted in the morphology of the skulls of the capitosaurid amphibians over time is currently in progress

D. Colloid and Surface Science/Environmental Pollution in Relation to Soil and Ground Water (Geochemical/Physicochemical Aspects)

The scope of Colloid and Surface Science is wide since it embraces multidisciplinary areas of research. Of these the fundamentals and applied aspects of self-organised amphiphiles, viz., micelles, reverse micelles and microemulsions, were undertaken for research. The application of microemulsions have been extended to numerous technological areas from tertiary oil recovery to nanoparticle synthesis. The availability of high interfacial area, combined with thermodynamic stability and the ability to solubilize otherwise immiscible liquids have led to the use of microemulsions in cosmetics, pharmaceuticals, lubricants, food technology, agricultural sprays, coatings, environmental remediation, cleaning, combustion, chemical synthesis, microporous media synthesis, enhanced reaction kinetics and chemical analysis.

Since most of the commercial surfactants used in industrial processes are mixtures of isomers and/or homologues, the investigations are aimed at to systematically study the basic phase behaviour of single surfactant (both nonionic and ionic) as well as mixed surfactant microemulsion systems. In formulating those microemulsions, attempts have been made to use biocompatible and non-toxic ingredients too.

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 like B.Stat (Hons.), M.Tech. (CS), M.Tech. (QROR) and other courses the scientists also guide and assist research students (towards the Ph.D. degree course) and research associates.

Research Activities

Topological field theory, Chiral anomaly and Berry phase, Quantum Hall Effect, Superfluidity, Quantum cosmology, Skyrminos.

Quantum field theory in flat and curved space time.

Quantum Mechanics of Anyons; Supersymmetric Quantum Mechanics; q-deformed Quantum Mechanics, Quantum optics, Confined Systems. Modified Airy Function Method is being applied to confined Quantum systems

Foundational Problems of Quantum mechanics, Quantum field theory by Stochastic quantization approach. Stochastic quantization of Gauge fields study of liquid helium using a new idea of quantization Quantum field theory of dissipative systems, Blackhole physics.

Extended Electromagnetic Theory

Wolf mechanism and alternate cosmology. Redshift phenomena, Massive eletredynamics. Recently a significant work has been done towards establishing a viable physical approach explaining red shift phenomenon without considering any particular cosmological model

Ionn distribution functions and Image analysis

Modelling Cerebellum and Cognition Process.

Antimatter searches, searches on the quak-gluon plasma (QGP) signatures and the properties of intermittency in high energy collisions are the central topics of interest

Solitary waves and double layers in plasma, and Dusty Plasma, Kinetic Alfven waves. It has been shown that finite ion temperature restricts the region of existence of solitons in Dusty Plasma.

Effects of rapid distortion theory and coriolis rotation on turbulent flow Modelling of turbulent flows with nonlinear terms, deductive theory for a homogeneous turbulent flow. Calculations of turbulence energy spectra, pressure spectrum etc

Hydrodynamic Stability, Fluid flow, Thin Film development, Stretching Sheet, Crystal growth It has been shown theoretically how a thermocapillary force helps to enhance the thinning rate and can achieve the desired thickness before the skin hardens at all.

Water waves, Mathematical methods, Inventory models.

Sediment transport, Dispersion processes, Navigation hydraulics, MHD flow and Heat transfer

Blood flow through artery, Two layer model, Hematocrit dependence, Temperature dependent viscosity, Effects of magnetic field, Blood flow in cardiovascular system.

Multivariate system and control theory; Design and Analysis of control systems; development of numerically reliable algorithms.

Pattern forming instabilities, Physics of Granular material, Fluid flows, Dynamical systems and Bifurcation theory

Biological Sciences Division

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

There are altogether 6 ongoing research projects and 2 externally funded projects in this unit. The ongoing projects are mainly conducted in two distinctly different ecological regions, namely Giridih region of Bihar plateau and Sundarbans region of South 24 paraganas, West Bengal. Farm Based studies are carried out in Giridih experimental farm with the focal theme on increasing cropping intensities and productivity through rainfed farming. Coastal region studies are botanical and ecological work on Mangrove vegetation and cultivation/introduction of oil palm and high yielding coconut varieties in the area.

Research Activities

Crop-Soil Weather Relationship

Objective of this project is to emphasize in-depth studies on weather parameter effecting moisture level in different land establish suitable cropping systems through proper utilization of rain water and select potential traditional and improved varieties producing stable yield under varied rainfall situation. Studies are also made to identify growth stages being affected by occasional droughts both in traditional and improved varieties and to identify suitable one in combating water stress. Now the studies have been mainly concentrated in collection and analysis of weather data of Giridih farm where besides rainfall, other parameters affecting productivity are also being studied. Farm based trials with emphasis on rice based systems were carried out this year with the above objectives.

During this year, attempts were made to correlate long term rainfall data with rice varietal performances during last 10 years in our farm on different topo sequences.

Technology Performance Studies

In phase II, few individual projects of previous years, are merged to a single project. This project with objective of selection of sustainable ecologically suited technologies, will attempt to study management in integrated trials so that we can come up with packages of farm practices related to crop/varieties on different land situations.

Following are the different aspects of studies carried out.

(a) Trials could identify suitable cultivars of rice, maize, pigeonpea etc. for rainfed farming through productivity criteria based on yield and stability.

(b) Different management practices were tried where few ecologically suited and economically accepted low input technologies have been suggested.

The work of phase II has started this year only, hence, data collection is in progress. Some results have already been achieved and data are being analysed. It has been established that totally eroded rocky upland/fallow land could be restored through aforestation programme within few years with a suitable combination of agro-forestry.

Subsistent Farming Studies of Bihar Plateau Region

This project was initiated to locate the status of resource utilization, constraints for technological adoption, and to identify and examine the indigenous knowledge systems of the villages while practising subsistence farming.

A survey work was conducted at the Usri watershed of Giridih area to probe agro-ecological constraints. These include microlevel rainfall pattern as affected by environmental changes, soil resource status, technology adoption by farmers etc. In order to gain intimate knowledge of technology adoption, a complete household survey of three villages was done in the watershed area with varying socio-economic systems, productivity, ecology and technology adoption rate. The data collected in this survey are being

analysed. During the year under review an attempt has also been made to analyse the resource data through GIS tools. This will continue in the next year.

Work on Palmae

The project deals with the study of various aspects of the family Palmae (Arecaceae) such as, developmental morphology, anatomy, phyllotaxy, ontogeny of endosperm in fruits, palynology, ontogeny of endosperm in fruits, palynology, ecology and conservation.

The phase I and II of this project dealt with comparative morphological and anatomical variations between seedlings and adult palms, ontogeny of stomata and trichomes, treachery elements of roots, and the effect of foliar spirality and sides of lamina on the density and size of stomata and trichomes of the leaf epidermis. Interesting findings were obtained from these studies. The phase III work deals with ecological anatomy of palms from different habitats, ontogeny of trichomes of leaves, and conservation of some endangered species. Further studies on these aspects are in progress.

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

The African oil palm and coconut are the two important oil yielding palms. Oil palm fruits contains 45-50% oil and coconut (copra) 60-80% oil. In view of this, the project was initiated in collaboration with the Department of Agriculture, Government of West Bengal in 1986 with the objectives : (i) to find out the possibility of introduction of oil palm and (ii) to select the most high yielding coconut palms among the well known high yielding cultivars, suitable in the Sundarbans. About 95% of oil palms and 40% of coconut palms started flowering. Further studies, particularly on the yield of fruits and growth behaviour are in progress.

Eco-floristic and Anatomical Investigations on Mangroves of Sundarbans

Mangroves are economically important woody halophytic plants which grow in the littoral zones of the tropical world. An attempt has been made to study the mangroves of Sundarbans with respect to their floristic survey, morphology of seeds and seedlings, anatomy of leaf, stem and root, palynology, ecology, and chemical characterization in view of their salinity stress, and medicinal properties. The project was initiated in 1989. Interesting results particularly on anatomical aspects were obtained. Further studies on root anatomy, chemical estimation of prolines and medical properties of leaves of different mangroves are in progress.

Projects Undertaken

SURDAC Project

Title Biodiversity of Sundarbans Mangroves and Identification of Eco-conditions for Rehabilitation of Some Endangered Species. This project was initiated in September, 1997. Mangroves provide rich and diverse living resources.

The mangrove forest of Sundarbans (2185 sq. km.) contributes 26.8% area to the whole forest mass of West Bengal. Among the important but endangered mangrove trees are 'Sundari' (*Heritiera fomes*), 'Passur' (*Xylocarpus mekongenesis*), 'Dhundul' (*X. granatum*) and 'Golpata' (*Nypa fruticans*). The present study will identify the vital ecological conditions necessary for rehabilitation of these plants. Hence the objectives of the project are :

(a) To study the species diversity of mangroves at varied ecological niches,

(b) To identify the eco-conditions of different mangrove species, and

(c) To suggest rehabilitation of the important endangered species of mangroves on the basis of the above study.

Faculty members of the AHGU regularly participated in teaching in B.Stat (Hons.) in Anthropology and M.Stat. in ASDA, SQC & OR under Biostatistics II and M.Stat. in ASDA, BSDA, SQC & OR under Statistical Methods in Genetic courses offered by the Institute. One faculty member is also teaching Anthropology at Calcutta University. Some of the faculty members are also engaged in Supervision of Ph.D theses. Two Research Fellows have already been awarded, two have submitted.

Research Activities

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

Human Adaptability Program

A. Health Status and Labour Productivity

Demographic information, which include census, fertility, mortality, self assessment of health and ailment symptoms, were collected from about 300 households.

Preliminary analysis shows that both fertility and mortality is comparatively lower in this population compared to their agricultural counterpart. Further analysis of the bio-medical data on agricultural labourers show less prevalence of hypertension and lung diseases in the agricultural population compared to tea garden labourers, physical activity of the agricultural labourers show maximum physical activity is attained at a specific age and the decline of the trait starts from a particular age also.

B. Effects of Microenvironmental Factors on Health in Rural Populations

The demographic data, collected from Munda (tribal) and Poundra (Hindu) living in the similar habitat and more or less same working pattern, indicate the following : The infant mortality rate among Munda was found to be marginally higher than in Poundra. However, the mortality rate among 1-5 years or toddler mortality was found to be significantly lower among Poundra than in Munda. This could be due to lack of toddler health care or the cultural beliefs of the Munda.

C. Women's Studies : Health & Well Being

Analysis of a part of data have been done, and the results obtained thereof have been used to prepare a Ph.D dissertation on the biological, psychological and social concomitants of old age individuals among groups of middle class men and women in Calcutta. Results showed that, biological problems (like hypertension and problems related to eyes and ears, digestive system, musculoskelatal systems etc) are more frequent in the retired group, specially among retired men. Psychological problems are more frequent in the non-retired group, specially among not retired women.

D. Determinants of Health Among the Hindus and Muslims Living at Different Cultural Settings

Health seeking behaviour is one of the main components of health culture of a community. Health culture is one of the major components of the total way of life of human beings.

Each community has its own cultural identity. With the development of various health institutions bring about changes in health culture of a community. Access to health services and health care delivery systems determine the cultural responses of the community.

A same community is sometimes found at different culture-complex (from remote rural village to the Industrial and further to stressful city). Thus there is a change in health culture at different social milieu.

With the above end in view, the Hindus and the Muslims living side by side in adjacent but different clusters will be selected from (1) a rural village in WB, (2) one Industrial town in WB and (3) an urban (stressful) slum in Calcutta city.

Anthropometric data (e.g. height, weight, etc.) are being collected from urban slum from mother and the children upto the age of 12 years, to assess the health status.

Data on health seeking behaviour and other cultural practices have been collected.

E. Modernization and Health in the Sikkim Himalaya

(a) Pre-testing of questionnaires pertaining to socioeconomic charactgeristics and individual modernity scale have been done.

(b) Analyses of data collected earlier have been done.

Genetic Diversity of Indian Populations

Based on data gathered from relevant publications, this project focuses on carrying out statistical analyses for obtaining a profile of genetic diversity and affinities among Indian ethnic groups on an all-India scale. The project is ongoing and data analysis are in progress.

Genetics of Complex Traits

During the year, we have focused on evolving statistical methods for mapping quantitative traits. We have proposed two methods for this purpose: first, when epistatic interactions are absent, and second, when such interactions are present. The first method is based on the EM-algorithm, while the second is based on ANOVA. Both methods have been shown to provide reliable estimates of parameters based on simulated data sets.

Human Ecology

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 increase in admixture with non-Gangtes is also apparent.

Population Structure and Human Variation

Human impact on biodiversity, interphase between forest dwelling communities and forest resources

Statistical analyses of different data sets collected earlier, are being persued. 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 populations. 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.

Genetics of Dermal Ridge

Research work on dermatoglyphic area namely finger, palm, toe and sole are being done over the last few years. The main objective of this project are (i) heredity of dermatoglyphics and (ii) heredity of dermatoglyphic asymmetry.

The existence inheritance as the dominant feature of dermatoglyphic trait is very well known However, estimation of inheritance pattern through proper hypotheses tests i.e. appropriate genetic models are lacking except only parent-child correlation method. The emphasis is therefore to find out if there is any role of a specific genetic model in determining pattern of inheritance of dermatoglyphic characters Various genetic models will be applied for example : Mendelian, Environmental, No Major Gene Effect, No Polygenic Component, Sporadic Models, etc. on 500 family data from 5 endogamous groups of West Bengal namely Brahmin, Mahisya, Padmaraj, Mulsim and Lodha Computer entry of palmar dermatoglyphic data of 5 populations, total individual 2439 and 56 variables for each individual, have been completed. Statistical analysis for the distribution pattern of 56 variables among 5 populations have been done by using a dermatoglyphic package (SPSS) developed by Kobyliansky et al., Tel Aviv University, Israel and the results will be incorporated in a report shortly. Statistical analysis of a few traits e.g. TFRC, ATFRC, a-b ridge-count of two populations namely Brahmin and Mahisya have been done using PAP Package. The results indicate that the genetic component in addition to environmental factora play a role in inheritance pattern of dermatoglyphic characters on both right and left side However, these findings cannot be interpreted as a final conclusion until the final analysis of entire data be made. The analysis and report writing will be continued.

Human Growth

Analysis of BMI data is in progress. A manuscript has been prepared Analysis of intercorrelations between BMI and the measures of body composition and body shape in different age periods from 7.0 to 16.0 years is in progress

Epidemiological Study

Detailed analysis of the data collected earlier have been done and preparation of the report is in progress.

Genetic Survey

Analysis of the data has been done The report is under preparation. Polymorphic, biochemical genetic marker has been screened among some tribal population from Agartala and DNA polymorphism analysis is in progress

Epidemiological and Clinical Studies

(a) Epidemiological profile survey data on "Diabetes" has been collected through family studies on Bengali Hindu population by enumerating the number of persons belonging to a Municipal Corporation/Panchayet 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

(b) Surgically incised organs - Appendix, Gall Bladder and Hernial Sac collected on Hindu Bengali individuals have been analysed to study histopathological and genetical changes Associations of organ issues with 4-polymorphic (PSM, ESD, AK and ACP) genetic loci have been studied. Further 6-monomorphic loci (LDH, MDH, 6PGD, G-6PD, CA_1, CA_3) have also been screened for detection of variants. In respect of Hernial sac significant association was found with Esterase D (ESD) and for Gall Bladder with Acid phosphatase (ACP).

Gene Environment Interaction

A. Oral cancer

Under this project present work is going on to uncover whether there is any susceptible genes for oral cancer in some individuals, who are being exposed to tobacco products, alcohol etc. One of the probable susceptible genes (GSTM1) at the DNA level both in oral cancer patients and matched control individuals have been studied. But no conclusion could be drawn now, since our sample size is small. So work is going on to collect more sample from patients and control individuals.

B. Human genome diversity

Genetic loci are being screened at the DNA level in different ethnic populations from different parts of India. Many more loci would be screened in the same population to get an idea of migration of population, affinity between populations etc.

Biochemistry Unit

The major cancer burden of the female population of India is the uterine cervic cancer. By the time most cases are reported, the stages are advanced and fatal. It has been projected that the number of annual incidence of 0.09 million in 1986 will be increased to 0.14 million by the turn of the century. Prevention and control of many of these premature death is, therefore, worthy of serious consideration, especially, in the context of women health in India.

Research Activities

Folic Acid in Cervical Preneoplastic and Neoplastic Diseases

Our study remained focused on women with cervical dysplasia/cancers to investigate several aspects of the role of folic acid in neoplasia. A major question is whether folic acid play any role in programmed cell death [PCD] (through apoptosis) during the process of normal maturation and differentiation of cervical epithelium versus in the abnormal cell proliferation? During 1996-97, we have standardized methodologies for identifying apoptotic bodies in the paraffin sections of formalin-fixed cervix tissues and in the epithelial cells obtained from cervical lavage preparations. Part of this work was presented in an international conference in 1996. Another was presented in an international conference in March 1997.

During 1997, we have further studied apoptosis in cells from cervical scrapes of women who are at risk for the development of cervix dysplasia/cancer along with controls. The study is ongoing and will be continued for at least two years.

Development of Vitro Model for Carcinogenesis/Tumorigenesis

There has been a need for a model system for the study of carcinogenesis/ tumorigenesis. The immediate objective is to establish a lymphocyte culture system and to explore the possibility of using it for developing aids/markers (through apoptotic mechanism) for tumorigenesis. The long term goal is to establish tumour cell line(s) and to use them in biomedical application (raising antibody etc.)

During 1996-97, we have standarized procedure for culturing human lymphocytes. Using these lymphocytes we studied the action of various (mutagenic/carcinogenic) drugs on the apoptotic principles.

In 1997-98, we have expanded our cell culture program by growing two cervix cancer cell lines, namely, Siha and Caski. These cells will be used as references for further studies on apoptosis and human papillomavirus.

Molecular Mechanism(s) of Defence Against Oxidative Stress : Cellular, Biochemical and Genetic Approach

Of various kinds of stresses that mammalian cells encounter, oxidative stress is being studied widely, because of the involvement of oxidant states in several degenerative diseases including aging and cancers. In earlier work, we have observed that by the pretreatment with a small non-toxic dose of H_2O_2, Chinese hamster V79 cells would develop resistance to H_2O_2, ionizing radiation and the alkylating agent MNNG. The induction of this resistance involves RNA and protein synthesis. We have further isolated a cell strain M5 (resistant to high concentration of the drug methotrexate, and with dihydrofolate reductase gene amplification) This strain was also radio/oxidant-resistant like its parent strain V79, subjected to low dose H_2O_2 pretreatment.

Our objective is to work on the underlying molecular mechanisms of such resistance in V79 and M5 cells to various oxidative stress(es). Data indicates that both cell types involve inhibition of apoptosis and reduced glutathione (GHS) level in resistance towards oxidative stress(es). While high GSH was responsible for the resistance in M5 cells, the parental V79 strain depicted resistance both at high and low GHS levels.

Human Uterine Cervix Cancer Database : Molecular Epidemiology (under SURDAC funding)

Cancer of cervix starts with a pre-invasive curable stage, cervix dysplasia, which is considered as a precancerous lesion. There is a large body of evidence which indicates that effective cervical cytology screening (Pap test) program could result in reduction of mortality from cervix cancer. Moreover, it becomes necessary to have an insightful grip on various relations and dynamics present among the key factors (such as Pap and HPV infection indicators, Age, Age at consumption of marriage (ACM) and Parity) of the process.

The process of cancer building is quite complex and nonlinear in nature. Keeping this in mind we adopt a 'forward search' approach to model building in this context.

In the first, we look into a Pap screening data collected from Calcutta Medical College hospital on 308 women to understand the nature of relationship between Pap indicator and other demographical and socioeconomic factors. A simple model search using multiple correlation identifies the major factors as Age, ACM and Parity for prediction of Dysplasia status. It, however, turns out that both the prospective and retrospective models have limitations. A careful investigation reveals some possible dependence between Pap status indicator and Parity. Moreover, the Pap indicator, which is obtained through cytological tests, show strong possibility of being subjected to measurement error.

This leads to the second component of investigation, where a regression analysis based on calibrated posterior (RACP) technique has been developed for scaling ordinal measurements using proportional odds model. This is applicable whenever experiments are replicated single subjects. No accurate set of measurements are necessary as required for usual calibrations.

The final phase encompasses a retrospective study on cervix cancer patients collected through in-depth field visits. In this study information on the presence of HPV (16/18) has been collected along with other cyto and histopathological information. This part is ongoing. Several descriptive statistical patterns and scientifically relevant hypotheses emerge from preliminary analyses.

Biometry Unit

Research Activities

Fishery Science

Experimental and quantitative Fishery Science to explore the growth and development of Indian major carps by judicious selection and application of supplemental feed. The longitudinal growth studies of the Indian major carps considering the biochemical parameters like protein, lipid, glycogen and digestive enzymes in laboratory condition with selected judicious diets have been studied. The degree of tolerance of pesticidal stress of the air-breathing fishes is also being investigated. Analysis of directional data generated from carp growth study is a new addition to the activity of this area of research.

The highlights of the results are :

(a) Average velocity and acceleration of growth rate of the Indian major carps have been determined (b) Satisfactory improvement of growth rates of the Indian major carps have been achieved by the application of supplemental diets.

Carp Growth and Histopathological Studies on Fish

Application of supplemental diets on Indian major carps under controlled laboratory condition reflects the changes of enzyme systems responsible for metabolic responses which effects the growth of the species.

Directional Data Analysis to Study the Growth Rate Pattern of Indian Major Carps

The optimal design in the placement of hoopnets according to the design of DD analysis have been worked out. Since a complicated entity, like growth of a living system, depends upon the external ambient condition as well as internal somatic system the infrastructure of this type of experiment needs some extra care and the same is almost at the stage of completion.

Longitudinal Growth Studies of Fresh Water Indian Major Carps Under Different Dietary Conditions

The infrastructure to generate the longitudinal data on carp growth is being persuaded. It needs to locate the 'problem area' of growth of carps by longitudinal study and its possible removal with an eye to having better growth of the species.

Investigation into Malnutrition Related Rickets and Fibro-Calculous Pancreatic Diabetes

Investigation into this problem is a novel and new one and we are the first to report this in Eastern India. The progress of this work upto this date is quite satisfactory. The data so far have revealed that it is not genetically inherited as only 11.2% of the first degree relatives amongst the patients are found to be diabetic. Since the patients posses high IgG and IgA levels in their serum, it is presumed that some immunological disturbances might have developed them. Studies of HLA-Class II antigenic associations in the patients show that they may be a sub-class of IDDM. C-peptide and Insulin assay clearly indicate the nutritional status plays an important role in them. It is also interesting that 60% of these patients show diabetic retinopathy. Histological study of liver and kidney of FCPD patients are being studied to compare them with that IDDM and NIDDM. Recently we are planning to undertake a pilot epidemiological study in order to reach a concrete conclusion about them.

Studies of Gymnemma Sylvestre as Controlling Diabetes

This is a new project which starts from April, 1996. The idea of taking up this project is to develop a hypoglycaemic drug from Gymnnemma Sylvestre, a well known and widely available Indian medicinal plant. Our present study works on a thorough and systematic probe to find out the active principles of this plant leaf extract which possesses antidiabetic activity with therapeutic relevance and also to find out the possible mechanism of its antidiabetic action. Upto now, the leaves of the plant from different places in different seasons have been collected. They are made air-dried and stored for follow up action. After ascertaining LD_{50} we have been now able to find out the working dose of the extract. This dose is now being tried to work on the animals under various conditions such as normal, induced diabetic and induced drug. It will one day unravel the mystries of Indian medicinal plant.

Chemistry Unit

Research Activities

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

B. Heavy metals in soil

Embryology Unit

Research Activities

Mathematical and Stochastic Modelling on Cellular Growth, Differentiation and Morphogenesis during Embryonic Development and Carcinogenesis

Mechanism of spontaneous pattern generation and emergence of ordered structure through self-organization has been further studied with special emphasis on the analysis of spatial structure and spatially variable membrane properties. Different standard mathematical models have been examined to investigate the role of high effective cooperativity which accounts for several binding sites of gene controlling proteins.

A model for the switching behaviour (determination) of a cell has also been considered and the main characteristic of a reactional system in the presence of diffusion in order to maintain inhomogeneities leading to spatio-temporal order have been investigated

A nonlinear reaction diffusion model of cellular differentiation and consequent pattern generation during embryogenesis has been proposed and analysed Inclusion of a negative cross diffusion can maintain a wave like solution and give rise to a dissipative structure has been confirmed by Hopfbifurcation analysis

Intercrop Interaction - A Mathematical Study of Agricultural Ecology

Allelopathy has an important role in agriculture Allelopathy is the effect of one plant upon another occurring under natural conditions and exerted by chemical means other than nutritional ones The allelopathic interaction between different pair of varieties of rice (*Oryza Sativa*) namely *Patnai* and *IET 2815 Patnai and Suharna, Kalam Kathi* and IR-36, *Radhunagagal* and *Ratna, Madhumalati* and *Jamuda* have been further investigated.

Another line of work deals with the study of weed-crop interaction We have studied this effect mainly on two weed namely *Crozophora* and *Leonurus* All parts of *Crozophora* produce inhibitors as observed by germination experiment with rice wheat and mustard Sinapic acid is identified as one of the allelopathic agent in the weed Another bi-Caliphatic acid with a molecular weight also act as allelopathic agents This substance requires further study for complete characterization Caffeic acid identified as one of the allelopathic agents in *Leonurus* We also studied the allelopathic effect of *Tamarindus* plants Vegetation under the tree is very sparse Root exudates and leaf leachate of these plants have been found to have inhibitory effects on germination of rice seeds but in constrast, the brown seed coat extract has been found to be stimulatory suggesting that the extract could be utilised as bioferti1izer

We have persued another line of work dealing with the nature of the fruit pulp It is well known that the pulp of many species of fruit contains inhibitors of germination This makes sense in the ecological perspective, for such inhibitors would not only prevent premature germination of seeds in the fruit still attached to the tree but also of those dropped from the tree and lying below Delayed germination should be to the interest of the tree because zoochoric agents can remove the inhibitors through their alimentary canal while dispersing seeds to distant points It is therefore of interest to study the germination-inhibitors of relatively little known tropical species

We have selected two less known tropical fruit namely *Icacia eruloba* and *Sterculia foetida*, the former is zoochoric and the later is non-zoochoric Both have a hard thick pod

The pulp extract of *Icacia eruloba* shows inhibitory effect but on paper chromatographic separation, three stimulators and three inhibitors were revealed

Sterculia foetoeda, this Indian fruit is encased in very hard, woody cover and so apparently need not contain any inhibitor In Laboratory experiment, the pulp extract shows inhibitory effect On paper chromatographic separation, two stimulators, one strong and one slight and one slight inhibitor were revealed

Pulp of various little known tropical fruit may contain inhibitors and stimulators which might be of value in agricultural practice For example, some inhibitors might be used on weeds for eradication and some stimulators on seedlings of crop for investigation

Mathematical Epidemiology

Further studies with mathematical and stochastic models of Japanese Encephalitis (JE), measles and other vector-borne diseases have been made with special emphasis on seasonal fluctuations and spatial spread An S → I → R → S (susceptible - infective - recovered - susceptible) epidemiological model coupling the dynamics of the spread of JE in two populations, human and reservoir animals (pigs, cattle, equines, birds etc.) through a vector population (particular species of mosquitos, *Culex vishnui, Culex tritaeniorhynchus* etc.) has been proposed and analysed It has been assumed that there is a constant recruitment rate of the susceptibles into both the populations whereas the death rates are proportional to the population sizes that is a

variable, one. We have also assumed that the human population is regulated by the disease. Conditions for the existence of a unique endemic equilibrium have been found and the endemicity of the disease is discussed. The criteria for eradication of the disease have been worked out. The analytical results corresponding to the solutions of our system are verified by numerical analysis and computer simulation. The dynamics of disease transmission of IF during 1948 - 1956 in Japan have also been investigated with the help of available data.

Diffusional Effects on Two or More Interacting Species in Community Ecology

The problem of interacting ecological species would be more visible if one can incorporate the epidemiological items also. The importance of transmissible disease in ecological situation is not to be ignored. The problem of a classical predator-prey dynamics in which the disease is spreading among the prey species only has been considered. The relative removal rate of the susceptible prey due to infection has been worked out. The small amplitude periodic oscillations bifurcating from positive interior equilibrium point has been observed. The stability as well as the direction of bifurcating branches has been calculated analytically by applying the algorithm due to Hassard which depends on the center manifold theorem. The following two important questions have been answered : Do prey disease increase or decrease the oscillatory tendency of predator-prey interaction? Can we possibly guess that the disease on the prey species acts as a biological control for predator-prey co-existence? Numerical solution and computer simulation have also given to substantiate the analytical results.

Some works have also been done in plankton allelopathy. Study of tremendous fluctuations in abundance of many phytoplankton communities is an important subject in aquatic ecology. A delay differential equations model of plankton allelopathy has been proposed and investigated to explain the occurrence of periodic bloom, succession and pulses observed in different plankton communities.

Plant Chemistry Unit

Research Activities

Screening of Local Vegetation

Screening of vegetation being a fundamental aspect of leaf protein work, work is continuing on new species. A field trip to the Agricultural Experimental Station, Giridih was undertaken to study the multiple uses of the various tree species growing in the lateritic tract of Bihar plateau. Soil samples were also collected from different locations and their nitrogen and organic carbon contents analyzed.

Microbiology and Technology

A short term *in vitro* study was conducted to determine the microbial population, the activity and the rate of decomposition of the mixture of fibre residues from two perennial plants viz. *Ipoma cilata* and *Trema orientalis* in the environment of forest soil in relation to moisture, temperature and pH. The most suitable condition was found to be 25% moisture content at 35°C and 6.5 pH for microbial association and fibre decomposition. The effect of temperature, moisture and pH on the species composition of fundal flora associated with decomposition were also investigated.

Nutritional and Biochemical Studies

Mineral contents of leaf proteins extracted from *Sesbania grandiflora* & *Moringa oleifera* was studied. *Moringa oleifera* was a good source of iron while leaf protein from *Sesbania grandiflora* was a better source of potassium. The gross energy content of *Sesbania grandiflora* was 5.1 K cal/gm. Amino acid content of the leaf proteins were also studied. Both had a high lysine content which indicated that the leaf proteins could be used to complement human diets.

Aquatic Weeds and Water Relationship

Fortnightly analysis of water quality parameters like pH, alkalinity, total nitrogen, total phosphorus and dissolved oxygen are being done on a local pond to assess changes in its water quality. Water weed

samples when present, are also harvested and the plant samples analyzed for dry matter, crude protein, and ash contents. This data will be used to study the relationship between aquatic plants and water quality of ponds where they grow.

Yield Performance

Utilization of sugarbeet root for ethanol production on a laboratory scale was undertaken. The recovery percentage of 85-90% was found to be quite promising. Though the success of sugarbeet crop as a source of alcohol by solid phase fermentation now requires trials on a large scale and estimation of practical costs, the present study indicates the future economic prospects in this direction.

Enzymes from Soil Microbes

A streptomycete (SI) with high proteolytic activity was isolated from soil of Gosaba, Southern West Bengal. Changes in proteolytic activities and growth as indicated by mycelial dry weight of SI with days of incubation in three different media were measured. It was noted that SI produces thermostable proteolytic enzymes in all the three media under study. Appreciable amount of enzyme is produced in media containing asparagine, gelatin and peptone as nitrogen sources and enzyme activity increased with the increase of incubation temperature.

Social Sciences Division

The Social Sciences Division includes the following units: Economic Research Unit, Economic Analysis Unit, Linguistic Research Unit, Planning Unit, Population Studies Unit, Psychology Research Unit and Sociological Research Unit. Economic Analysis Unit is located at Bangalore, 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 faculty members of this Unit were engaged in teaching and research activities, including supervision of Ph.D. students. Two Ph.D. students submitted their theses. The faculty, as in previous years, took active part in teaching all economics, econometrics and time-series courses in B.Stat. (Hons.), M.Stat., M.Tech. (QROR), ISEC (both regular and specialization) programs. With the starting of the new two-year Master of Science (MS) programme in Quantitative Economics from 1996-97, the teaching responsibility of the faculty of this Unit has increased substantially. 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.

Research Activities

Economic Theory

Research works on various areas in economic theory have been done in the last year. Some of these areas are: macro theory, general equilibrium analysis, welfare economics, economic efficiency, industrial organization and general aggregation issues.

Industry

Some studies have been carried out to evaluate the performance of Indian Industries in terms of Productivity, Efficiency and Growth with special emphasis on the impact of liberalization of Indian economy. Both industry level and firm level studies were done and it was found that there is no significant impact of on-going liberalization process on the performance of Indian industries. The studies suggest that Indian industries are still under the grip of monopoly elements instead of expected rise in competitiveness.

Economic Development and Macro-Economic Policy in India

Studies on financial liberalization, role of money, credit and government finance, budgetary policies etc. are being carried out in the Unit.

International Trade

Research is 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 studies which focused on the cooperative and non-cooperative R and D behaviour of competing firms as also of joint ventures, merger and other connected problems.

Agricultural Economics

A study was undertaken to examine some implications of farm efficiency on the basis of a sample of 597 paddy cultivating farms in West Bengal for the year 1989-90 using the non-frontier profit function technique with translog specification.

The method proposed in the study tries to take account of the economic environment of the farmer.

In another study the relation between the agricultural price seasonality and market arrival seasonality of wheat and rice was examined.

Studies on Consumer Behaviour and Level of Living

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.

Another study focused on the measurement of the cost of children which is an issue of central importance in policy related matters like poverty, income distribution, income maintenance programs, child benefit programs etc.

Econometric Methods and Applications

The areas under Time Series Econometrics in which research is being carried out are : autoregressive conditional heteroscedastic (ARCH) models and time varying risk premia models. A conditional counterpart of mean-Gini capital asset pricing model in which the risk is taken to be time varying has been suggested, the estimation and testing of hypothesis aspects of this model are being look into.

Some of the areas in applied econometrics include (a) optimal commodity taxation, (b) employment fluctuation/uncertainty, (c) non-parametric demand analysis, (d) causality between social development and economic growth, (e) estimation of frontier production function and (f) seasonality with Indian stock exchange data. Here the day of the week effect and also the turn-of-the-year effect on return data on Indian stock exchanges are being studied. In the framework, both the approaches to studying seasonality viz., deterministic and stochastic seasonality have been considered.

Corporate Finance

Studies on the interaction of real and financial decision of firms were carried out in the Unit. Some broad issues include capital budgeting, capital structure, payout policies, corporate governance, mergers takeovers and leveraged buy outs, corporate restructuring, bankruptcy and corporate reorganization.

Economic Analysis Unit

The Unit was actively engaged in research in the areas of agricultural economics, measurement of poverty, economic policies and econometric methods and applications

Research Activities

Savings-Investment Intermediation
Liquidity Preference Function

Impact of Economic Reforms

Game Theory

Macroeconomic Theory

Growth

Variability and Stability of Cereal Crop Yields in India

Units Roots and Cointegration

Wagner's Law on Public Expenditure

Applied Bayesian Methods in Economics

Impact of External Assistance on India's economy

Linguistic Research Unit

During the period under review, the Unit continued its programme of research in the areas of Quantitative Linguistics and Computational Linguistics with special emphasis on Speech Pathology, Psycholinguistics, Sociolinguistics, Syntax and Text Analysis as described below

Research Activities

Computational Linguistics

A. Valency-based Natural Language Processing

B. Fuzzy Logical Expressions in Bangla

C. Problem of Conceptual Tense and Aspect vis-a-vis Grammatical tense in Bangla Discourse

D. Legitimacy Crisis of Computational Linguistics

Methods in Quantitative Linguistics

Studies on the phonetic and phonological structures of major Indian languages and applications

A. Speech Pathology

B. Second Language Acquisition

C. Cultivation of Mother-tongue

D Language Standardization

E Comparative suprasegmental studies on Indo Aryan and Dravidian

SocioIlnguistics

A Study of language attitudes

B Language maintenance and shift

C Measurement of bilingualism

D Glottopolitics of linguistic sub-alternity and decentralized language planning in a plural society

E Analysis of Folklore and Folklanguage

Habilitation programme for hearing impaired children

Projects Undertaken

The present objective of the Unit is to develop methodology for the quantification of micro and macro linguistic data using statistical and computational techniques. In spite of substantial application of statistics in the realm of linguistic research there is no indigenous and integrated method for statistical-linguistic analysis appropriate to the Indian situation. Therefore we wish to develop a methodology covering different fields of linguistics, computer science and statistics. The following areas are covered.

Comparative Suprasegmentals of the Indo-Aryan and Dravidian Languages

The main objective of the project is to analyse the suprasegmentals of specific languages within the broad Indo-European group. Various types of interrelationships among some of the major languages of the Indian sub-continent are being explored with a view to measure the statistical distance between them. In order to study the spontaneous stress patterns in interrogative, exclamatory and imperative sentences, a map task (Edinburgh map task) test was administered to eight pairs of Bengali speakers. Tape recordings have been made of the guided discourse and the analysis is being done with the help of appropriate instruments.

Language Processing and Planning in the Indian Plurilingual Perspective

The project devotes solely to the problem of computational parsing of Bangla Language with a view to planning language in the Indian milieu. The problem is being dealt with in four phases. In the 1st Phase the emphasis will be on the order of Bangla verb in sentences and the typology of Bangla sentences will also be taken into account. In Phase 2, the importance of the verb in projecting the structure of Bangla sentences from the semantics point of view will be undertaken. In Phase 3, we plan to explore different possibilities of Bangla verb combinations and Phase 4 will supply the rules for these combinations (particularly compound verbs) and exceptions to these rules. Statistical analysis of the combinatory rules is also planned.

Habilitation of Hearing Impaired Children

The Unit carried out habilitation of hearing impaired integrated in general schools at its habilitation centre throughout the year. Consultation services have also been offered to other institutions training hearing impaired children, and counseling of parents and teachers of hearing impaired children has also been undertaken.

Planning Unit

The faculty of the Planning Unit was very much involved in basic research, applied research as well as teaching in economics. Instead of Ph.D. and one-year of Masters students only, it now teaches a full-fledged, two-year Master's program (MSQE).

Its faculty members have published in top international journals such as *Journal of International Economics, Review of Development Economics, Journal of Policy Reform and Journal of Economic Theory*. A textbook on macroeconomics was published. Important projects on applied topics were completed - namely, *Counting the Poor* sponsored by the Department of Statistics and published already in a book form, *Regional Disparities in Growth and Infrastructure* and *Gender Bias* all pertaining to the Indian Economy (the last two projects supported by PPRU).

The spectrum of research has broadened. It now includes economic growth and infrastructure, international trade and distribution of wealth and income, international trade and environment and industry-wise econometric studies. The applied-economics expertise of the unit members continues to be used by various governmental organizations and other institutions.

The Planning Unit hosted its 12th Annual Conference on Economic Theory and Policy in January 1998. There were a large number of participants from within the country and from abroad. In particular there was a session on applied works on the Indian economy.

The recently instituted Masters program has considerably enhanced the visibility and direct service of the Planning Unit to the society. It competes with best such programs in the country such as in Delhi School of Economics and Jawaharlal Nehru University.

Population Studies Unit

Research Activities

The main broad areas of research of the Unit include demographic transition in India, studies on migration, evaluation of literacy programme.

Agriculture Development, Child Labour and Fertility

This study tries to find out the interrelationship between agriculture development, child labour and fertility. Child labour is defined under several categories such as, wage earning child labour (i.e. work for earning) and domestic child labour (i.e., work in the family farm or household, part time or seasonal). A sample of about thousand households were selected at random from rural areas of two blocks respectively from the district of Hooghly and Midnapore in West Bengal.

Preliminary findings show that the demand for wage earning child labour increases in the household with development and modernisation of agricultural farm but has a negative relation with fertility. However the household with traditional agricultural management in the farm has a positive relation with domestic child-labour as well as fertility. Supply of child labour in the household with modern farm management comes from the household with no agricultural land or a marginal farmer and fertility is higher among this group.

Digit Preference Error in Age Data : Implicit Model Approach

Indices have so far been constructed to measure the extent of digit preference error in age data (single year) either from census or survey. All indices possess deficiency in their constructions. As such modifications are done at different steps by different researchers and modified indices sometimes are of little value in their use because of cumbersome calculations. The present method, however, tries to highlight some theoretical conditions under which all the extraneous sources of variations are eliminated implicitly in a single attempt leaving behind a true index.

Women Education and Employment in India, 1951-1991

The study is undertaken to find out the pattern of growth of education and employment of women and the differential rate of growth of sectors over time. Data collection from secondary sources is in progress.

Demographic Study of Santals of Medinipur District of West Bengal

A pilot study on the project entitled Demographic Study of Santals of Medinipur District of West Bengal has been started in April 1997. The study will examine a variety of demographic processes that impinge on the size, structure and viability of the minority population. For the purpose the major tribal group, Santal has been considered which comprised 54 per cent of total tribal Population and about 66 per cent in Medinipur district in 1981. To have further information village level data have been collected from the 1991 Census on the Medinipur district which are under process. This study is confined in the Jhargram block, which is Santal dominated. Five villages have been selected comprising Santal population as total, around 75 per cent, 50 per cent, 25 per cent respectively. A set of questionnaires has been prepared and canvassed in the selected villages. The land records of these villages in the Block Land Reforms office have also been searched to collect data on the main asset and land of the villagers. The collection of data from the records and the household survey have been completed.

Study of Fertility and Mortality in West Bengal : Trends, Levels and Patterns

West Bengal, a constituent state of India, has been facing the problem of rapid population growth during the last five decades. This population growth is determined by its components : fertility, mortality and migration. Migration data being meager and often flawed in the census, have been ignored in the present study. Recently developed indirect methods have been applied to census data to estimate these parameters and these estimates have been substantiated by the estimates obtained from National Family and Health Survey data as well as from SRS estimates. This study has been completed in December 1997.

Migration in India

Objective of this study is to highlight internal migration flow and Nepali migration in India. Nepali migration has never assumed a status of large scale exodus at any point of time in the past. The work based on 1951-81 census data is complete. Data on 1991 census have been compiled form floppies which are available just now. Nepali migrants show a declining trend. But during 1981-91 the volume of migrants have fallen significantly so that there has been a negative growth rate. The study is in progress.

Impact of Total Literacy Campaign in the District of Birbhum - An In-depth Study

A study on the Impact of Total Literacy Campaign in the Districts of Birbhum and Bankura of West Bengal (sponsored by Govt. of W.B.) was undertaken in the year 1993. The report of the Project was submitted to the govt. Now further attempts are being made to study the impact of the programme in terms of behavioural change and to develop method of quick assessment of the programme. Data entry has already been completed. Analysis of data is in progress.

Mortality and its Determinants in India

The purpose of this research is to analyse SRS data on mortality over the two decades following 1970. The study involves the national level as well as the regional level. Attempt is being made to study the mortality trends and determinants, and in particular those of infant, child and old age mortality.

Estimation of Volume of Illegal Migrants from Bangladesh

The independence of Bangladesh in 1971 created a vast displacement of population between Bangladesh and India, specially eastern region. Frequent crossing of borders continues to be a political flash point between Bangladesh and eastern region of India. Large number of migrants from Bangladesh tend to hide their identity. Large volume of refugees from Bangladesh, a densely populated poor country, has created political and economic problems in this region of India. Poverty, unemployment, social security and

increasing pressure of population on land forces the people to take shelter in other neighbouring places. Still no systematic approach has been made to examine social, economic and political impact of migrants from Bangladesh to eastern region of India. An attempt has been made to estimate the volume of illegal migrants from Bangladesh to West Bengal using Census records.

Population data by age and sex and place for all districts as well as for total West Bengal have been collected and compiled with the help of computer from 1961 to 1991 census records. Migrations data for all districts and also for total West Bengal have been collected since 1971 to 1991. Derivation of methodology is under progress.

Publication of a Commemorative Volume of Professor Ajit Das Gupta's work in Demography

The primary objective of this proposal is to collate and compile the vast array of Ajit Das Gupta's (ADG) contributions to demography in a single volume. All his pioneering studies, being either not all documented or scattered in various journals, monographs and reports, are not easily available to the present generation of students and researchers. But for tracing the development of Indian demographic research, it is essential to have a thorough insight of ADG's scholarly and methodological work on population during the three decades (1950-70). The work is in progress.

Child Labour in India and Its Determinants

This study examines the status of child labour (i.e., work participation of children aged 6-14 years) in India and its major states by various socio-economic and demographic characteristics from National Family Health Survey Data, 1991-93. Factors associated with the incidence of child labour is explored through multivariate statistical analysis.

Psychology Research Unit

The Unit organized a training programme on measurement of employee satisfaction to the managers of Asia Brown Boveri Limited (ABB), Bangalore from 22nd to 26th September, 1997. The programme was conducted by D. Dutta Roy.

Research guidance for the Ph.D. students of different Universities have been given by S. N. Banerjee during this period. One of them has been awarded the Ph.D. degree by the Calcutta University during this period.

Research Activities

The scientific workers of Psychology Research Unit have been carrying out research work in the area of Entrepreneurial behaviour, motivation to work, primary education etc.

Potential Entrepreneur School Leavers

A scale for measuring entrepreneurship potentiality has been developed to identify potential entrepreneurs from among the young boys and girls who can independently start some business or manufacturing units for their livelihood. The scale has been developed on the basis of data collected from trainee entrepreneurs and established entrepreneurs by taking into account some essential psychological characteristics. Data analysis for establishing psychometric properties and report writing is going on.

Motivation to Work for Primary Level Workers

For assessing the motivational level of primary level workers a questionnaire has been developed on the basis of pilot study done on a group of 52 workers, 346 data from three groups of workers for e.g., Clerks, Typists and Factory workers have been collected. Analysis and report writing is going on.

Attainment level of Primary Students at the end of Class IV in West Bengal (Particularly the Non-scholastic Achievements)

An ongoing project aims to obtain a clear picture of the Non-scholastic achievements of the primary students of the state of West Bengal covering all the 18 districts. During this period sampled schools of six districts have been contacted through the District Inspectors of Schools and Chairpersons of the concerned District Primary School Councils. At the same time data have also been collected from the schools of four districts contacted earlier. Simultaneously scoring, tabulation and computer data entry from evaluation are also in progress.

Statistical Analysis of Influence of Personal, Social and Background Variables on Academic Achievement of Primary School Students (SURDAC funded)

The objective of the study is to develop a Rasch type probabilistic latent trait model to measure the ability of primary school children directly related to academic achievement. The objective is also to develop a quality based approach to measure the deviance from target of the primary education process. The model has been developed on the basis of a field experiment done in a primary school in Madhyamgram. The model has been tried out on the data from Murshidabad district collected during base-line survey of District Primary Education Programme. In future, the other DPEP districts will be taken into consideration for model fitting.

Gender Study for the District Primary Education Programme

An in-depth gender study for the District Primary Education Programme has been undertaken in three districts, namely, Birbhum, Murshidabad and Coochbehar of West Bengal. Special emphasis is being given to look into the problem of girl students, specially minority girls. Field work in all the districts have been completed. Analysis and report writing is going on.

Sociological Research Unit

The faculty members of Sociological Research Unit (SRU) participated in teaching Sociology for B.Stat. students. Guidance is also provided to Ph.D. scholars in Anthropology at Calcutta University.

The Second ISI Review Committee recommended that SRU should consolidate and expand its academic activities pivoting round the broad theme of social transformation. In pursuance of this crucial recommendation, the scientific workers of SRU have been carrying out their research projects, both external and internal, in areas which have direct implications in understanding the rubric of social transformation. The Unit has also given emphasis on collaborative research work with the scientists of other disciplines belonging to different units of ISI in the event of internal as well as external projects.

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 urbanization, 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 of stocks of handicraft and machine-made products in the villages, exploration in Palamau area to measure the impact of development plans on the [illegible] population, eco-systemic programme of work and agro-sociological collaborative study on rain-fed 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 1 lakh filled-in questionnaire schedules which was unanimously accepted by the ISI Council.

Research Activities / Projects Undertaken

Forest protection and income generation for the tribal poor - evaluation of an organized movement

A pilot survey has recently been carried out in Ilambazar block of Birbhum district which is being followed up by a comprehensive field work for collecting empirical data in order to assess the relevant impact of (i) land reforms, (ii) decentralized Panchayat-oriented planning process, (iii) literacy movement, and (v) organizational activities of the local peasant organizations in motivating the Forest Protection Communities in the Champahati jungle in the Ilambazar block in the district. The process of data analysis is going to be undertaken soon.

Involvement of people in the decentralized planning process : Experiences in West Bengal

The study aims at (i) assessing the extent of involvement of the people right from planning (at village level) down to in implementation, (ii) gaining an insight into the efficiency of villagers in utilizing the resources (material and human) and the constraints of full capacity utilization, (iii) comparing the efficacies of earlier District Plans implemented at village level. Through analysis of data gathered in course of examining relevant documents on plan-performance gaps etc. as well as in field-level investigation, the study seeks to suggest concrete measures which are needed in higher aggregate level of planning.

The study has already been initiated in Midnapore and Purulia districts by examining various Gram-Panchayat Samity level plans and reports and through identification of appropriate respondents at village, block and district levels.

Scope and constraints of rural women leadership with special reference to experimentation in local Self-Government bodies

Generally the participation of women in politics and social work was rare specially in the rural areas, excepting some notable examples. Women participated in the freedom struggle and in different democratic and class struggles, but their number was very small specially because of their social status in the society. However, due to long-drawn movements by women for equal status with men there was some change in the Constitution in order to ensure legal sanction for their participation in political and social activities. Our enquiry starts from this point, after reservation of seats for them in local self-Government bodies (i.e. in three tiers of Gram Panchayat) has been allotted.

A report (for 1995-96) has already been completed and submitted.

Three Gram-Panchayats from each of the districts of Midnapore and Birbhum were undertaken for formulating the socio-economic and cultural profiles of women leaders. Data collection has been completed. Final report is being prepared.

Interpersonal contacts and social development : A rural experience in West Bengal

In the changing rural scenario it seems that individuality is gaining its strength. Instrumental use of personal relation is very much associated with the process. Social development in terms of mobilisation of the scarce resources by the individual person is very much likely to be influenced by the nature and context of the personal contact of the individual. Thus, besides other factors, the role of personal contact of the individual, as such, deserves attention.

In this study we attempt to understand the role of personal contact in the process of motivating the individual for securing the scarce resources and sustaining it. The essential task of the study is field work, i.e., selection of locality, establishing communication with local Panchayat and other key persons relevant for the purpose. Deucha Mouza of Md. Bazar in Birbhum District is selected for investigation.

Chamars and Santhals of Giridih

In Bihar, Chamars and Santhals are demographically predominant among the Scheduled Castes and the Scheduled Tribes and they are distributed throughout the State. Besides, it is generally assumed that the impact of urbanization and industrialization is associated with social change, as also with the 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.

As regards collection and computation of available data, satisfactory progress has been achieved regarding the Chamars. List of villages having a total of 5,539 Chamar households and that of 16,131 Santhal households have been prepared to facilitate sampling procedure.

Transfer of ownership of properties and changing social scenario in Calcutta - A sociological analysis

Calcutta is one of the most important commercial centres of India. Three centuries back Calcutta started its life as a trading centre and that is still continuing to-day. Occupations of the inhabitants here are diverse in nature. With various language differences, different socio-economic, cultural and institutional traits these people formed distinctly different social-cultural groups and settled in different localities within the city of Calcutta.

Due to the increasing trend of population density of Calcutta, demand of housing has become, during the last few decades, extremely acute. This opened up land market to the promoter-contractor nexus. Earlier this process of transfer of property was a sort of gradual, slow change which has now become abrupt and conflict-ridden. Under this purview, the proposed study is to enquire the following.

(a) To identify the socio-linguistic groups in different parts of Calcutta metropolis which are involved in the phenomenon of transfer of ownership of land and residential housing.

(b) To make an outline of the socio-cultural, economic and other related factors of these who have been or are being uprooted from the original settlements.

(c) To examine whether a process of alienation has started as a consequence of this social situation.

Role of family and local community in elder care : An exploratory study

Traditionally the elder care in our society has mostly been the responsibility of the family. The elderly members are expected to be considered as an integral part of the family. They serve the roles of important resource 'person' of knowledge and wisdom, preserver, propagator, and protector of culture while taking part in domestic chores. The national system of generational co-residence was, therefore, mutually beneficial and hence, remained widespread in India.

But in recent past, various socio-economic changes, i.e., industrialization, urbanization, migration, etc. have affected intergenerational cohesion and solidarity. The joint family structure has also started breaking down due to pressure of rapid social changes. It is also observed that nuclear and small-sized families have become the numerically dominant mode of living.

The project will make an attempt to examine the current status of the role of family as well as community in providing elderly care for identifying the problems and assessing their various aspects in two purposively selected areas in West Bengal.

Collection of information about the households having 60+ persons of 10 sample wards from north Calcutta and 6 sample wards from south Calcutta covering 259 households was made from the sample households surveyed by the Calcutta Metropolitan Development Authority. The same source was tapped for obtaining data from the 12 wards of Serampore town. The town sample consisted of 101 households having elderly members. From the district of Burdwan a relatively remote village under the Mangalkot P.S. was

selected to gather information about the households having aged members. The village Palashi had 61 households having 60+ members. A few case histories were also collected from the village.

Statistical Quality Control and Operations Research Division

Introduction

The basic objective of the Division is to propagate the use of SQC, OR and allied management techniques for controlling loss and cost, improving quality and augmenting productivity in Indian industry. The Division continued its activities in developing professionally competent specialists in Quality Control, Reliability and Operations Research (QCR & OR), imparting inplant appreciation and technical training in QCR & OR for different levels of personnel, undertaking project studies and service assignments, promoting the use of quantitative tools and adoption of modern methods of Quality Management, and also undertaking theoretical and applied research in the relevant fields.

Academic Programs

The Division is running a two year M.Tech. course to turn out professionally competent specialist for industry. At present 11 engineering graduates and 9 M.Sc. (Statistics) students are attending the course. The Division also offers a Specialist Development Programme (SDP) to provide career in industry through on the job training and guided development. Besides, evening courses are organised at Bangalore, Hyderabad and Chennai. The Division also provides faculty supports for the SQC & OR specialisation at the M.Stat. programme.

Consultancy Services

The Division has earned a reputation for providing consultancy services in all areas of Quality Management and Productivity. At present 140 organizations throughout the country are taking services of the Division. Besides this, the different SQC & OR units are vigorously pursuing Quality System work related to ISO 9000 certification, and providing consultations in this area to over 60 organizations. The Division has also conducted certification audit on behalf of KEMA, Holland at 10 organizations for ISO 9001/9002 Quality Assurance System standards.

ISO 9000 Survey 1996

During the last four years, more than one thousand companies have been certified for ISO 9000 Quality Assurance System Standards. The SQC & OR Division has conducted a survey to evaluate the degree of competitive edge which the certified companies have been able to gain. The findings of the survey were brought out in August, 1997. Salient findings of the survey include the following :

(a) The main motivation for seeking ISO Certification was customer demand (68%) followed by the desire to prevent nonformance (54%).

(b) ISO Certification has been reported to be instrumental in (i) better understanding of processes and responsibilities (66%); (ii) improvement in communication leading to better management control (45%), and (iii) better linkage to other functions (40%).

(c) More than 60% of the companies reported poor/no awareness of SQC/SPC concepts.
Mr. U.H. Acharya and Mr. Sanjit Ray coordinated this survey.

Quality Improvement Projects-Highlights

(a) In a plant, the occurrence of inlet shrinkage defects was brought down from 15.1% to 0.2% by using control charts. Other defects like round-punch defects and die-side shrinkage defects were also reduced from 4.5% to 0.7% and from 3.3% to 0.5% respectively during the same time period.

(b) A comprehensive project has been carried out in an electrical industry to reduce the total through-put time of circuit breakers. Process mapping has been done for the entire activity and disconnects have been

identified at interfaces. Using Statistical Techniques, remedial actions have been taken to remove the disconnects. Ideal process has been mapped and implemented.

(c) Using Robust Engineering methodology, two new motors with improved performance characteristics have been developed in two client companies.

(d) A special project has been taken up on 'Evaluation of cost of Poor Quality' in an IT Company. This study highlighted major area of concern and 6-sigma projects have been initiated on 5 major high yielding areas.

The extent of consultancy, inplant and general training programs are summarized below :

(i)	No. of industrial Units served	: 140
(ii)	General training programs	
	No. of programs	: 32
	No. of participants	: 450
(iii)	Inplant programs	
	No. of programs	: 124
	No. of participants	: 2850
(iv)	Seminar/Talks	
	No. of programs	: 36
(v)	No. of promotional visits	: 83

The details of training programs and a partial list of factories served under consultancy programme are given in Appendix A & B (Page 78 and 83 respectively).

Quality Mission Project (QMP)

Quality Mission Executives (QME), under Quality Mission Project continued their active participation in conducting training programme and rendering Quality System related consultancy services to industries and service organizations. One of the major assignments that QMEs undertook is supplier development programme for a major multinational company which manufactures refrigerators and washing machines. A special programme for the senior executives of leather industry jointly sponsored by Council of Leather Exports and Central Leather Research Institute was also organised.

During the current year, the QMEs have rendered services of 215 days in consultancy, 60 days in training programme and have trained 1797 persons at various levels in industries and service organizations. The QMEs are actively assisting ten organizations in implementations of ISO/QS 9000 Quality Systems.

The performance of QMP has been reviewed by a committee chaired by Prof. J.K. Ghosh. The committee has recommended further continuation of project for another five years and certain changes in focus. This has been subsequently approved by the Govt. of India. Recruitment of new batch of QMEs is on progress.

Training Course

Tailor made in-house programs to suit the specific requirements of different organizations were conducted for about 95 plants. A large number of short duration courses were conducted on Statistical Process Control and Industrial Experimentation. A number of appreciation and motivation courses were conducted for

workers in regional languages for a few organizations. 32 general training programs were also organised during the period under review.

Research activities

The research activities of the Division covered areas like optimum sampling plan for detection of defects in defect interference, effect of welding parameter on weld metal chemistry, Fuzzy Goal Programming, construction of repeated measurement designs, sensitivity analysis of decision plans, continuous sampling plan, sensitivity of S/N ratios, inference in Linear models, LCP, stochastic games, Symmetric games, Pivoting algorithm, Non Zero sum Stochastic games, Perfect information stochastic games, Multivariate calibration method, HAT matrix, Optimal sampling of bulk materials with multi-characteristics etc.

During the year under review, 13 papers were published in different journals; 7 were published in conference proceedings; 2 were published in books; 8 were accepted for publication in different journals and 6 were sent for publications. The book 'Quality Case Studies', edited by C.R. Prasad has been published by the SQC & OR Division, ISI. A Monograph on linear Models and Regression is under preparation by Dr. P. Bhimasankaram.

Mr. A.K. Chakraborty has been awarded Ph.D degree by the Indian Institute of Science, Bangalore for his thesis on 'Software Quality Testing and Remedies'; while Mr. D.K. Manna has been awarded Ph.D degree by the ISI for his thesis on 'CTV Minimization in Single Machine Scheduling'. Mr. T.K. Dutta submitted his Ph.D thesis entitled 'Construction of Some Combinatorial Design Arising out of Statistical Experiments' to the ISI. Two research scholars attached to the Division are working in the areas of OR/SQC.

Other activities

A. Statistical Survey of Knitwear Industry : The survey is in final stage of analysis.

B. Publications : Quarterly News Letter of the Division is being published as per schedule.

C. Collaborative Projects :

(i) A special project on 'Enumeration of Mail through sample survey in Delhi and West Bengal' is being carried out for the Department of Post and Telegraph, Ministry of Telecommunication, Govt. of India

(ii) Prof. S.C. Chakravarty was a member of the team for the project entitled "Tracer Study of ITI Graduates" funded by the Directorate General of Employment and Training, Ministry of Labour, Govt. of India.

(iii) Prof. P.R. Lakshmikanthan initiated a project on "Line Balancing Using Priority Concepts for Customers", together with Prof. N.K. Jaiswal in M/S. Gapp's Industries Ltd.

(f) Collaboration with other Organisations : Collaborative work were undertaken with the American Supplier Institute, NIQR, KEMA (Holland), IAPQR, Transport Planning Department, BIS, Foundation for Organisational Research, RBI, FICCI, CII, Central Road Research Institute, Productivity Councils etc.

Staff Development Programme

During the year under review, six faculty members of the Division successfully completed the QS 9000 AIAG registrar training organised by IRQS at Mumbai during June, 1997. 23 faculty members attended the ISO 14000 Advanced Environmental Audit Programme organised by FICCI Quality Forum at New Delhi; while one faculty member successfully completed the ISO 9000 Lead Assessor Programme Organised by TQMI Pune in July, 1997.

Mr. Shin Taguchi, President, American Supplier Institute, conducted a two days programme on Robust Design using Taguchi Method during July 17-18, 1997 at Calcutta. The programme was attended by 51 persons including four from industry, 3 from Applied Statistics Division and 2 from Stat-Math Unit.

Management Development Centre at Hyderabad

In line with the recommendation of the Sukhatme committee, work has been initiated for establishing a Centre for Management Development. It is expected to start functioning soon.

Library, Documentation and Information Sciences Division

Documentation Research and Training Centre (DRTC), Bangalore

The activities of DRTC have been organised into several programs, such as (a) Research Programme, (b) Advisory Services Programme, (c) Publication Programme, (d) Educational and Training Programme, (e) Employment Information Programme, (f) Continuing Educational and Training Programme and (g) Faculty Development Programme.

Training in Documentation and Information Science

Course leading to "ADIS" Award :

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

Short-term Course on Computerized 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), Govt. of India, New Delhi, the DRTC is conducting a six-week course on "Computer Applications to Library and Information Work" since 1986. This year, the DRTC conducted the 19th Short-term course.

Research Activities

The main areas of research in which the different members of the DRTC faculty were engaged during the period, April 97 to March 98 are furnished below :

(1) The study of various methods of knowledge representation, such as, semantic nets, frames, and predicate calculus, etc (2) The application of the modern scientific management techniques to the planning and management of information system, centres and services (3) The study of the methodologies of information analysis and consolidation. (4) The development of bibliometric, scientometrics measures for evaluating the use of library and information services and scientific output respectively (5) The preparation of guidelines and actual development of software and application packages for library house keeping operations, such as, circulation control, serial control.

Projects Undertaken

Library Automation

A Project on software development for library automation is being carried out. Many modules for Serial Control were developed - creating a database of journals in ISO 2709 format, to upgrade the databases, to generate indexes, to print selected or all records, to print invoice, subscription letters, etc. In addition to these modules, a module for Cataloguing, and a module for Acquisition Control are being developed since April 97. Program to compute circulation statistics and detailed user manual has to be written.