UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 22nd (3/2024) meeting held on 30.09.2024, the Syndicate in its 69th (1/2025) meeting held on 17.01.2025 has approved the revised curricula of the following academic programs for implementation w.e.f Spring 2025:

1. M.Phil in Statistics **(Annex-'A')**
2. Ph.D in Statistics **(Annex-'B')**

(WAQAR AHMAD)
Additional Registrar (General)

No. SU/Acad/25/349

Dated: 20.03.2025

Distribution:

- Chairman, Department of Statistics
- Controller of Examinations
- Director Academics

C.C:

- Dean, Faculty of Sciences
- Director, QEC
- Additional Registrar (Affiliation & Registration)
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

Annex-'A'

SCHEME OF STUDY

AND

COURSE OUTLINE

FOR

MASTER OF PHILOSOPHY PROGRAM

IN STATISTICS

Session Spring 2025 Onward

DEPARTMENT OF STATISTICS

UNIVERSITY OF SARGODHA

13/7/2025

Chairman Department Statistics
University of Sargodha

1. **Nomenclature of the Program**

Master of Philosophy in Statistics

2. **Department Brief:**

The Department of Statistics has a reputation for outstanding teaching, research and consulting services. The department offers an opportunity to students to diversify their talent in different new emerging fields of statistics. The department plays an important role in terms of producing graduates fully equipped with modern data analysis tools.

The department of Statistics was formally established in Spring 2008, having 376 graduate level students and 49 postgraduate level students. Apart from the core courses, numbers of optional ones are also offered to train students from theoretical and practical aspects. Statistical computing plays a major role in the programs offered by the department as one of the aims is to produce students who can immediately work as applied statisticians by covering all theoretical concepts. To promote data literacy, the department train young talent of Pakistan to apply appropriate statistical tools to get more insights about the data/problem at hand. This not only helps to understand key issues during data collection but also promotes data driven innovations. Weekly assignments/practical work makes extensive use of standard statistical packages including MINITAB, SPSS, R, Mathematica, Python etc., which are installed on the computers in the well-furnished computer laboratory.

3. **Program Learning Objectives:**

1. To educate students regarding the major tenets of statistics both in applied and theoretical statistics with application knowledge in their own areas as well as related areas of other disciplines.
2. To prepare them for the job market by teaching them statistical packages and programming languages.
3. To advise them about designing, carrying out and presenting an original and publishable work of research at the leading edge of statistics.
4. To provide them with rigorous classroom training in theory, methodology, and application of statistics, and provide them the opportunity to work with faculty on advanced research topics.
5. To train them regarding explaining their work orally and identifying areas of future research in statistics.

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4. **Program Structure**

Duration	Minimum 1.5-Years (3-Semesters), Maximum 4-Years (8-Semesters)
Entry Requirements:	Candidates having minimum 2nd division in annual system or CGPA 2.0/4.0 in MA/M.Sc/LLB/BS(4-Years)degree (16 years of education) in semester system in Statistics and Data Analytics subjects from HEC recognized Institutions.
Intra-disciplinary fields allowed for admission	Biostatistics Data Science
Degree Completion Requirements:	Total Credit Hours of Course Work: 24 Total Credit Hours of Thesis/Courses In Lieu of thesis: 06 Total Credit Hours of Program:30
Program Mode	i) Thesis Track ii) Coursework Track

5. **List of Deficiency Courses of Level-6:***(for intra-disciplinary admissions only)*

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	STAT-6101	Regression Analysis	3(3-0)	Nil
2.	STAT-6102	Probability and Probability Distributions-I	3(3-0)	Nil
3.	STAT-6103	Sampling Techniques-I	3(3-0)	Nil
4.	STAT-6104	Design and Analysis of Experiments-I	3(3-0)	Nil
5.	STAT-6110	Statistical Inference-I	3(3-0)	Nil
6.	STAT-6112	Time Series Analysis	3(3-0)	Nil
7.	STAT-6114	Applied Multivariate Analysis	3(3-0)	Nil

6. **List of Mandatory/Compulsory/Core Curses:**

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	STAT-7101	Advanced Probability Theory	3(3-0)	Nil
2.	STAT-7102	Survey Sampling	3(3-0)	Nil
3.	STAT-7103	Advanced Statistical Inference	3(3-0)	Nil
4.	STAT-7104	Linear Models	3(3-0)	Nil

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7. List of Elective Courses:

Sr. No.	Course Code	Course Title	Credit Hours	Prerequisite
1.	STAT-7105	Advanced Multivariate Analysis	3(3-0)	Nil
2.	STAT-7106	Advanced Categorical Data Analysis	3(3-0)	Nil
3.	STAT-7107	Applied Stochastic Models	3(3-0)	Nil
4.	STAT-7108	Measure Theory	3(3-0)	Nil
5.	STAT-7109	Inference in Stochastic Processes	3(3-0)	Nil
6.	STAT-7110	Optimization Techniques	3(3-0)	Nil
7.	STAT-7111	Medical Statistics	3(3-0)	Nil
8.	STAT-7112	Analysis of Clinical Trials	3(3-0)	Nil
9.	STAT-7113	Survival Data Analysis	3(3-0)	Nil
10.	STAT-7114	Logical Reasoning and Research Methods	3(3-0)	Nil
11.	STAT-7115	Analysis of Repeated Measures	3(3-0)	Nil
12.	STAT-7116	Applied Logistic Regression	3(3-0)	Nil
13.	STAT-7117	Bayesian Decision Theory	3(3-0)	Nil
14.	STAT-7118	Advanced Operations Research	3(3-0)	Nil
15.	STAT-7119	Numerical Analysis and Stochastic Simulation	3(3-0)	Nil
16.	STAT-7120	Mixture Distributions	3(3-0)	Nil
17.	STAT-7121	Mathematical Demography	3(3-0)	Nil
18.	STAT-7122	Multi-level Modeling	3(3-0)	Nil
19.	STAT-7123	Bayesian Analysis	3(3-0)	Nil
20.	STAT-7124	Generalized Linear Models	3(3-0)	Nil
21.	STAT-7125	Statistical Machine Learning	3(3-0)	Nil
22.	STAT-7126	Non-Linear Estimation	3(3-0)	Nil
23.	STAT-7127	Statistical Process Control	3(3-0)	Nil
24.	STAT-7128	Time Series Analysis	3(3-0)	Nil
25.	STAT-7129	Spatial Data Analysis	3(3-0)	Nil
26.	STAT-7130	Analysis of Multi-Factor Designs	3(3-0)	Nil

8. Thesis:

1.	STAT-7150	**Thesis**	6	

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Scheme of Studies

Master of Philosophy in Statistics

Semester-I

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-1*	STAT-61XX	Course will be decided from list of Deficiency courses	3(3-0)	Nil
Complusory-1	STAT-71XX	Course will be decided from list of Compulsory courses	3(3-0)	Nil
Complusory-2	STAT-71XX	Course will be decided from list of Compulsory courses	3(3-0)	Nil
Elective-1	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil
Elective-2	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil

*** For Intra-disciplinary admitted candidates only**

Semester-II

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-2*	STAT-61XX	Course will be decided from list of Deficiency courses	3(3-0)	Nil
Complusory-3	STAT-71XX	Course will be decided from list of Compulsory courses	3(3-0)	Nil
Complusory-4	STAT-71XX	Course will be decided from list of Compulsory courses	3(3-0)	Nil
Elective-3	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil
Elective-4	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil

*** For Intra-disciplinary admitted candidates only**

Semester-III& IV

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency-3*	STAT-61XX	Course will be decided from list of Deficiency courses	3(3-0)	Nil
Research		Thesis	06	Course Work Completion
Courses in Lieu of Thesis				
Elective-5	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil
Elective-6	STAT-71XX	Course will be decided from list of Elective courses	3(3-0)	Nil

Note: Courses may be decided from the list of Compulsory and Elective courses.

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Program Summary:

Category	Minimum No of Courses	Minimum No of Credit Hours
Deficiency Courses	03	09
Compulsory Courses	04	12
Elective Courses	04	12
Thesis or Courses in Lieu of Thesis	02	06

Note:

i) The Regulations related to MS/M.Phil./M.Sc.(Hons) or equivalent approved by the Syndicate from time to time shall also be applicable.

ii) Deficiency Courses are to be decided by Graduate Program Committee in start of each session.

iii) Department can change the order of Core/Compulsory and Elective Courses as per availability of resources or demand.

iv) Department can change the course offering as per available resources but shall be uniform for one session.

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STAT-7101 **Advanced Probability Theory** **3(3-0)**

Probability theory is the branch of mathematics that deals with modeling uncertainty. It is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. A probability distribution is a statistical function that describes all the possible values and likelihood that a random variable can take within a given range. Therefore, decision processes must be able to deal with the problems of uncertainty. Uncertainty creates risk and this risk must be analyzed. In many situations large amounts of numerical data are available which requires statistical techniques for analysis. The course will give the student a deeper understanding of the foundations of probability theory, such as probability theory from a measure-theoretic perspective, convergences of distribution and probability measures, and conditional expectations. During the course, important theorems, such as uniqueness theorem, Kolmogorov strong law of large numbers, monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions. Lindeberg's CLT and its particular cases, Cramer's theorem on composition of convergence in distribution and convergence in probability will be investigated.

Contents

1. Algebra of sets, fields and sigma-fields, limits of sequences of subsets, sigma-field generated by a class of subsets, Borel fields.
2. Probability, measure on a sigma-fields, probability space, continuity of a probability measure.
3. Real and vector-valued random variables, distribution functions (d.f.) discrete r.v.s., r.v.s of the continuous type,
4. Decomposition of a.d.f, independence of two events and (n>2) events, sequence of independent events, independent classes of events.
5. Dynkin's theorem, independence of r.v.s, Borel zero-one law. Expectation of a real r.v. and of a complex-valued r.v. Linear properties of expectations, characteristic functions, their simple properties, uniqueness theorem.
6. Convergence of a sequence of r.v.s., convergence in distribution, convergence in probability, Kolmogorov strong law of large numbers (without proof)
7. Monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions.
8. Lindeberg's CLT and its particular cases
9. Cramer's theorem on composition of convergence in distribution and convergence in probability.

Recommended Texts

1. Hogg, R., Tanis E. & Zimmerman D. (2015). *Probability and statistical inference*. (9th ed.). Prentice Hall.
2. Billingsley, P. (1986). *Probability and measure*. New York: John Wiley & Sons.

Suggested Readings

1. Feller, W. (1969). *Introduction to probability and its applications*. New York: John Wiley & Sons.
2. Loeve, M., (1978). *Probability theory* (4th ed.). USA: Springer.
3. Stuart A. and Ord J. K., (1998). *Advanced Theory of Statistics*. Volume I: Distribution Theory. (6th ed.). Edward Arnold.

STAT-7102 **Survey Sampling** **3(3-0)**

Sample surveys are an important source of statistical data. A great many published statistics on demographic, economic, political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. The aim of this course is to cover sampling design and analysis methods that would be useful for research and management in many fields and to develop your understanding of the principles and methods used to design the survey sampling schemes. The aim of this course is to impart knowledge about survey sampling techniques and its applications. This course deals with the response, response error and response variance. Course is also concerned with both categorical and regression analysis in complex surveys and effects of survey design on regression analysis. This course deals with the basic concepts of sampling, requirements of a good sample, determination of sample size etc. Ratio and regression estimates of simple random sampling are also the parts of the contents.

Contents

1. Non-Sampling Errors, Observational Errors
2. Incomplete Sampling
3. Nonresponse, Effects of Non -response, Response and Response Variance.
4. Sources of Response Error
5. Detection, Control and Measurement of Response Error,
6. Scaling Methods, Types of Scales, General Procedure in Attitude Scaling
7. Rating Scales, Likert Scale, Guttman Scale
8. Sematic Differential.
9. A Survey of Super population Models. Randomization theory results for SRS Model for SRS. and model for ratio and Regression Estimation
10. Model for Stratified Sampling, Cluster Sampling
11. Models for unequal Probability Sampling, Complex Surveys
12. Variance Estimations in Complex Surveys.
13. Categorical Data Analysis in Complex Surveys
14. Regression Analysis for Complex Survey
15. Effects of Survey Design on Regression Analysis.
16. Effects of Two-stage Sampling on OLS Methods
17. Comparison of Domain Means in Two-stage Sampling.

Recommended Texts

1. Mukhopadhyay, P. V. (2005). *Theory and methods of survey sampling*. Prentice-Hall.
2. Cochran, W.G. (1996). *Sampling techniques*. New York: John Wiley & Sons.

Suggested Readings

1. Raj, D. & Chandhok, P. (1998). *Sample survey theory.* New Dehli: Narosa Publishing.
2. Lessler, J.T. &Kalskeek, W. D. (1992). *Non-sampling errors in surveys*. New York: John Wiley & Sons.

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STAT- 7103 **Advanced Statistical Inference** **3(3-0)**

Statistical inference is the process of using data analysis to deduce properties of an underlying distribution of probability. The goal is to use probability theory to make inferences about population parameters of interest. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. The course deals with testing of hypothesis, distribution free and randomization tests, interval estimation and scalar parameters. Statistical inference attempts to isolate the decision maker of his personal opinion and preference to achieve an objective conclusion that is supported by the data. This course also involves derivation of power functions of different tests for comparing and evaluation of the tests. Robust estimation, maximum likelihood estimates, and robust inference for location parameters are also the part of the course. Inferential statistics help to draw conclusions about populations by using small samples. Consequently, it provides enormous benefits because the entire population cannot be measured. Statistical inference is important in order to analyze data properly and proper data analysis is necessary to interpret research results and to draw appropriate conclusions.

Contents

1. Objective of statistical analysis and theory, criteria for the choice of families of models, the likelihood, sufficient statistics, some general principals of statistics inference.
2. Significance tests: simple null hypothesis and simple alternative hypothesis, some example, discrete problems, composite alternatives, two-sided tests
3. Local power, Multidimensional alternatives, composite null hypothesis, similar Region, invariants tests
4. Distribution– free and randomization tests: permutation tests, Rank test, Randomization tests, distance tests, Interval estimation: Scalar parameter, scalar parameter with nuisance parameters
5. Vector parameter, estimation of future observations
6. Point estimation: General considerations on bias and variance, Cramer Rao inequality
7. Achievement of minimum variance and remove of bias, estimates of minimum mean squared error
8. Robust estimation, Asymptotic theory: Introduction, maximum likelihood estimates, large sample parametric significance tests, Robust inference for location parameters.

Recommended Texts

1. Hogg, A.V., McKean, J.W., & Craig, A.T. (2005). *Introduction to mathematical statistics* (6th ed.). USA: Pearson Prentice Hall.
2. Casella, G., & Berger, R. L. (2002). *Statistical inference.* (2nd ed.). USA: Duxbury Press.

Suggested Readings

1. Mood, A. M., Graybill, F. A. &Boes, D. C. (1997). *Introduction to the theory of statistics.* McGraw Hill.
2. Stuart, A. and Ord, J .K. (1998). *Kendall's advanced theory of statistics.* Vol. I. London: Charles Griffin.
3. Lehman, E.L. (1997). *Testing statistical hypotheses.* USA: Springer.

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STAT-7104 **Linear Models** 3(3-0)

This course is designed for M.Phil in Statistics students. In many areas of science, technology, social science and medicine one often wishes to explore the relationship between one observable random response and several 'factors' that may influence simultaneously the response. So, this course introduces students to statistical model building using the improved class of linear models. To study such cases, linear models and regression analysis are the main tools. The main goal of creating a model is to predict the future value of the dependent variable. The process of finding this mathematical model that best fits the data involves regression analysis. Generally, regression analysis is a collection of methods for determining and using models that explain how a response variable (dependent variable) relates to one or more explanatory variables (predictor variables). This course will also enable the researchers to find out the factors that affect the response variable of a particular problem. The various components of the course will improve the research and analytical thinking abilities of the students, as well as their capacity and motivation for intellectual development. In the end, some statistical software i.e. R and Mathematica may be considered to improve the computing skills of the students in fitting regression models.

Contents

1. Regression models and their types
2. Definition and forms of linear models.
3. Least square estimation method
4. Assumptions of the linear model
5. Best linear unbiased estimator
6. Gauss-Markov Theorem.
7. Generalized Least squares Method
8. Maximum likelihood estimation method
9. Model goodness of fit and related inferences
10. Biased estimation methods
11. Robust estimation methods
12. Outlier and influence analysis
13. Predictions from Regression with different estimation methods.
14. Linear model-based profiling.
15. Linear model fitting with different statistical software

Recommended Texts

1. Belsley, D.A., Kuh, E. and Welsch, R. (1980). Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. New York: Wiley.
2. Christensen (2011) Plane Answers to Complex Questions: The Theory of Linear Models. Springer.
3. Draper, N.R. & Smith, H. (2004). Applied regression analysis. New York: John Wiley & Sons.
4. Kutner, M.H., Nachtsheim, C.J., Neter, J., and Li, W. (2005). Applied Linear Statistical Models, 5th Edition. McGraw Hill, New York.

Suggested Readings

1. Agresti, A. (2015). Foundations of linear and generalized linear models. New York: Johan Wiley & Sons.
2. Christensen, J. (2002). Advanced linear modeling. U.S.A: Springer.
3. Baltagi, B. H. (2011). Econometrics (5th ed.). U.S.A: Springer.

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STAT-7105 **Advanced Multivariate Analysis** **3(3-0)**

Multivariate analysis uses statistical tools to determine the relationships between factors. Essentially it is a tool to find patterns and relationships between several variables simultaneously. It lets us predict the effect a change in one variable will have on other variables. This course is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. This course deals with multiple variable analysis simultaneously. The course includes principle and factor component analysis which is a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables. It identifies patterns in the correlation between variables. It also includes multivariate analysis of variance which is a procedure for comparing multivariate sample means. As a multivariate procedure, it is used when there are two or more dependent variables and is often followed by significance tests involving individual dependent variables separately. Advantages of multivariate analysis include an ability to glean a more realistic picture than looking at a single variable. Further multivariate techniques provide a powerful test of significance. The multivariate model is a popular statistical tool that uses multiple variables to forecast possible outcomes.

Contents

1. Principal Component Analysis (PCA), PCA for standardized variables, PCA for variance covariance matrix and special structures, Interpretation of PCA
2. Decision about Components, Scree plot, Large sample inferences.
3. Factor Analysis (FA), Orthogonal FA, methods of estimation: PCA, MLE
4. Factor rotation and Factor scores.
5. Discriminant Analysis (DA)
6. Classification of population by Fisher approach, Evaluation of classification functions
7. Canonical Correlation (CC), identification of canonical variates, CC and its link to multiple regression.
8. Cluster analysis
9. Hierarchical methods, single, complete and average linkage, Non-hierarchical methods, K-means methods.
10. Path analysis
11. Multivariate Analysis of variance (MANOVA)
12. Multivariate Regression
13. Multivariate Nornaml Distribution
14. Wishart Distribution
15. Hoteling T^2

Recommended Texts

1. Anderson, T.W. (2003). *An Introduction to multivariate statistical analysis*. New York: John Wiley & Sons.
2. Johnson, R.A. & Wincher, D.W. (2004). *Applied multivariate statistical analysis*. London: Prentice Hall.

Suggested Readings

1. Hair, J.F., Anderson R.E., Jatham, R.L. & Black W.C. (1998). *Multivariate data analysis*. (5th ed.). Pearson Education.
2. Flurry, B. (1997). *A first course in multivariate statistics*. New York: Springer.
3. Tabachnick, B.G. & Fidell, L.S. (1996). *Using multivariate statistics*. (3rd ed.). Harper Collins College Publishers.

STAT-7106 **Advanced Categorical Data Analysis** **3(3-0)**

This course is designed to introduce basic concepts and common statistical models and analyses for categorical data; to provide enough theory, examples of applications in a variety of disciplines (especially in social and behavioral science); and practice using categorical techniques and computer software so that students can use these methods in their own research; to attain knowledge necessary to critically read research papers that use such methods. This course is laser-focused on logistic regression modeling and how to interpret these models, rather than the theory behind them. Prescribed course is concerned with the applicable knowledge about statistics in the field of categorical nature of variables. Course is aimed at providing students with a formal treatment of categorical data specifically in the social sciences and decision making theories based on behavioral and attributional variables. This course also covers the brief concepts of advanced categorical methodologies comprising generalized linear modeling with their mathematical derivations. Course communicates the high skills to play the major role in statistics by using the multinomial response models and Poisson regression model. The course is heavily oriented with tools for analyzing categorical data with practical applications.

Contents

1. Introduction to categorical data analysis, Principles of likelihood-based inference, Sampling distributions for contingency tables
2. Measures of association for 2x2 tables.
3. Testing independence in contingency tables
4. Exact inference for two-way tables, Inferences for three-way tables.
5. Introduction to generalized linear models
6. Logistic Model building
7. Alternative link functions for binary outcome, Diagnostics, Exact methods
8. Conditional logistic regression.
9. Methods for analyzing matched case-control data
10. Multinomial response models for nominal data.
11. Multinomial response models for ordinal data
12. Poisson regression model, Poisson regression for rates
13. Log-linear models for contingency tables
14. Negative binomial models
15. Quasi-likelihood and Generalized Estimating Equations.

Recommended Texts

1. Agresti, A. (2010). *Analysis of ordinal categorical data*, (2nd ed.), John Wiley & Sons.
2. Anderson, E. B. (1994). *The statistical analysis of categorical data*. USA: Springer.

Suggested Readings

1. Anderson, E. B. (1994). *The statistical analysis of categorical data*. USA: Springer.
2. Bishop, Y. M., Fienberg, S. E. & Holland P. W. (2007). *Discrete multivariate analysis*. USA: Springer.

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STAT-7107 **Applied Stochastic Models** **3(3-0)**

Stochastic processes are the natural tool to model real-world phenomena involving randomness and uncertainty. They offer a powerful mathematical framework to analyze complex problems in a variety of applied areas, ranging from business and industry to economics, finance, social sciences, and biology and computer science. Moreover, the use of stochastic processes to build advanced statistical models is central to the ongoing data science revolution. The main focus is on modeling aspects, which are completed by a description of some popular algorithms for simulation. Mathematical concepts are integrated with real-world applications and examples. Forecasting and predicting for the future is a significant factor for planning and development of any organization in this running world. Purpose of introducing this course is to handle stochastic process, predicting such types of process by using probabilistic approaches by using probability distribution techniques. Course is compiled by including the probability generating function, Markov processes, emigration process and some more advance techniques in this context. At the end of the course, students have bridged the gap between their elementary probability skills and the knowledge required to understand and use basic models based on stochastic processes.

Contents

1. Probability generating, functions
2. Compound distributions
3. Simple random walk
4. Branching processes.
5. Markov process
6. Discrete time Markov chains
7. Continuous time Markov chains
8. Birth-death process.
9. Immigration and emigration process
10. immigration-death processes
11. Renewal processes.
12. Markov renewal process
13. Ergodic theorem
14. Gaussian processes
15. Brownian motion.

Recommended Texts

1. Gikhman&Skorokhod (2007). *The theory of stochastic process III*. USA: Springer.
2. Cox, D. R. & Miller, H. D. (1965). *The theory of stochastic process*. Chapman and Hall.

Suggested Readings

1. Feller, W. (1968). *An introduction to probability theory and its applications* (3rd ed.). New York: John Wiley & Sons.
2. Melhi, J. (1982). *Stochastic processes*. Wiley International Ltd.
3. Stirzaker, D. R. (1982). *Probability and random processes*. London: Oxford University Press.

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STAT-7108 **Measure Theory** **3(3-0)**

A measure on a set is a systematic way to assign a number to each suitable subset of that set, intuitively interpreted as its size. In this sense a measure is a generalization of the concepts of length, area and volume. Measure theory is the formal theory of things that are measurable. This is extremely important to probability. Measurement theory is the study of how numbers are assigned to objects and phenomena, and its concerns include the kinds of things that can be measured, how different measures relate to each other, and the problem of error in the measurement process. Measurement theory shows that strong assumptions are required for certain statistics to provide meaningful information about reality. In statistics, the term measurement is used more broadly and is more appropriately termed scales of measurement. Course is aimed to cover the different measure those are frequently used in statistics like lebesgue and outer measure of the set of information. Course highlights the practical appliance of the measurable function and the Riemann integral of a bound function over a set of finite measure. Course also signifies the importance of integral of non-negative function and measurability of the outer function. Course extends the convergence theorems and bounded linear functional on Lp space representation theorems.

Contents

1. Lebesgue measure, introduction, outer measure
2. Measurable sets
3. Lebesgue measure, a non-measurable set.
4. Measurable functions. Labesgue Integral
5. The Riemann integral of a bounded function over a set of finite measure.
6. The integral of a non-negative function.
7. The general Labesgue. General measure
8. Integration, measure space
9. Measure functions, integration
10. General convergence theorems
11. Signed measure, Hahn decomposition theorem.
12. Outer measure and measurability
13. The extension theorems
14. Convergence in measures.
15. Some related topics: the Lp space
16. Holder and Minkowaski inequalities
17. Convergence and completeness
18. Bounded linear functional on Lp space rieaz representation theorem.

Recommended Texts

1. Roydon, H.L. (2010). *Real analysis* (4th ed.). New York: Collier Macmillan Co.
2. Barru, G.D. (1981). *Measure theory and integration.* Ellis, Harwood Ltd.

Suggested Readings

1. Khan, A.R. (1993). *Introduction to lebesgue integration.* Pakistan: Illmi Kitab Khana.
2. Folland, G.B. (1999). *Real analysis-modern techniques and their applications* (2nd ed.). New York: John Wiley & Sons.
3. Rudin, W. (1980). *Real and complex analysis.* McGraw Hill.

STAT-7109 **Inference in Stochastic Processes** 3(3-0)

A stochastic process can be defined as a collection of random variables that are indexed by some mathematical set, meaning that each random variable of the stochastic process is uniquely associated with an element in the set. A stochastic process is a collection of random variables defined on a common probability space, taking values in a common set S and thought of as time. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of inference in stochastic process, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Markov sequences, estimation of parameters based on likelihood and conditional least squares, auto-regressive series. It deals with the estimation of martingale strong law of large numbers, CLT for martingales parameters, Diffusion processes and their likelihood, properties of estimators. It also discusses the properties of estimators on the non-extinction path, asymptotic distribution theory. Elements of semi-parametric and non-parametric analysis, theory and applications of optimal estimating functions, estimation of transition and stationary density, intensity function of a counting process are part of the content.

Contents

1. Inference in Markov chains, estimation of transition probabilities
2. Testing for order of a Markov chain,
3. Estimation of functions of transition probabilities, parametric models and their goodness of fit
4. Markov sequences, estimation of parameters based on likelihood and conditional least squares, auto-regressive series.
5. Statement of martingale strong law of large numbers and CLT for martingales
6. CAN property of the MLE from a general sequence of dependent random variables, Fisher information. Applications to Markov chains and sequences.
7. Likelihood of Poisson and other Pure Jump Markov processes from first principles, CAN property of MLE's
8. Testing for a Poisson process, non-homogeneous processes.
9. Analysis of parametric Pure Jump processes, Birth-Death-Immigration processes, testing goodness of fit of such models.
10. Diffusion processes and their likelihood, properties of estimators (without proof) Branching processes
11. Inconsistency of MLE/moment estimators.
12. Properties of estimators on the non-extinction path
13. Asymptotic distribution theory.
14. Elements of semi-parametric and non-parametric analysis
15. Theory and applications of optimal estimating functions, estimation of transition and stationary density, intensity function of a counting process.

Recommended Texts

1. Bhat, B. R. (2000). *Stochastic models: Analysis and applications*. New Age International Publishers.
2. Basawa, I.V. &PrakasaRao, B. L. S. (1980). *Statistical Inference for stochastic processes*. Academic Press.

Suggested Readings

1. Adke, S. R. & Manjunath, S. M. (1984). *An introduction to finite markov processes*. Wiley Eastern.
2. Guttorp, P. (1991). *Statistical inference for branching processes*. New York: John Wiley & Sons.

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STAT-7110 **Optimization Techniques** **3(3-0)**

The course covers developments of advanced optimization models and solution methods for technical and economic planning problems. The basis of the course is the optimization process, from a real planning problem with interpretation of the solutions of the underlying optimization problem. In the modeling part we focus on problems with discrete elements, but also knowledge about important classes of optimization problems and their properties will be highlighted. Prescribed course provide applicable knowledge related to Statistics in the concern of convex sets, supporting and separating hyper-planes techniques. This course aimed to impart basic and applied knowledge about optimization and its applications in different fields of marketing to model the balanced and unbalanced transportation problems. This course highlights the Gomory cut method skills of branch and bound method. Course also enlightens the significance of mathematical modeling based strategies based on both mathematical and applied nature of disciplines on the Management. description measures of data for interpretation of results, and decision making. It also deals with constraint programming, local search, and mixed-integer programming from their foundations to their applications for complex practical problems in areas such as scheduling, vehicle routing, supply-chain optimization, and resource allocation.

Contents

1. Convex sets, supporting and separating hyper-planes, program and basic feasible solution, simplex algorithm and simplex method, two phase method, graphical solution, Charnes' M-technique.
2. Duality in linear programming, duality theorems,
3. Dual simplex method with justification, sensitivity and parametric LPP.
4. Transportation and assignment algorithms, balanced and unbalanced transportation problems, degeneracy
5. Hungarian method of assignment, transshipment problems.
6. Integer-linear programming
7. Gomory cut method, branch and bound method, fractional cut method
8. Network flows, maximal flow in the network, labeling technique, connection between network flow and transportation, matrix solution. Nonlinear programming.
9. Integer Programming
10. Goal Programming
11. Quadratic programming
12. Kuhn - Tucker conditions
13. Algorithms (Wolfe's Beale's and Fletcher's) for solving quadratic programming problem.

Recommended Texts

1. Sharma, J. K. (2009). *Operations research theory and methods* (4th ed.). Macmillan.
2. Hadley, G. (1987). *Linear programming*. London: Addison Wesley.

Suggested Readings

1. Taha, H. A. (1992). *Operations research.* (5th ed.). Macmillan.
2. Kambo, N. S. (1991). *Mathematical programming techniques*. Affiliated East-West Press Pvt. Ltd.

STAT-7111 **Medical Statistics** **3(3-0)**

Medical statistics is the study of human health and disease. Its applications ranging from biomedical laboratory research, to clinical medicine, to health promotion, to national and global systems of health care to medicine and the health sciences, including public health, forensic medicine, epidemiology and clinical research. It is the science of summarizing, collecting, presenting and interpreting data in medical approach and using this data estimate the magnitude of associations and test hypotheses. It has a main role in medical investigations. Statisticians help researchers design studies, analyze data from medical experiments, decide what data to collect, help interpret the results of the analyses, and collaborate in writing articles to describe the results of medical research. Medical statisticians design and analyze studies to identify the real causes of health issues as distinct from chance variation. It explores the heterogeneity of effects, their interactions, sensitivity and specificity of the applied statistical terminology. This course also signifies the practical appliance of the hazard models, survival analysis and cross-control study designs. The goal is to provide students. to the community with high skills to play the major role in statistics by using the knowledge of biological variables and their communicating results of epidemiological studies.

Contents

1. Study designs in epidemiology.
2. Measures of disease occurrence and association
3. Variation and bias.
4. Identifying non-causal association
5. Confounding.
6. Defining and assessing heterogeneity of effects, interaction.
7. Sensitivity and specificity of diagnostic test, Cohort Study designs, statistical power and sample size computations.
8. Log-linear models, 2xK and 2x2x2 contingency tables
9. Logistic model.
10. Analysis of binary data.
11. Cross-control study designs, matched case-control studies.
12. Survival data: Proportional hazards model, multivariate survival data.
13. Causal Inference
14. Longitudinal data.
15. Communicating results of epidemiological studies
16. Ethical issues in epidemiology.

Recommended Texts

1. Selvin, S. (2004). *Statistical analysis of epidemiological data*. Oxford University Press.
2. Diggle, P. J., Heagerty, P., Liang, K., & Zeger, S. L. (2002). *Analysis of longitudinal data*. Oxford University Press.

Suggested Readings

1. Piantadosi, S. (1997). *Clinical trials: A methodologic perspective*. New York: John Wiley & Sons.
2. Agresti, A. (1990). *Categorical data analysis*. New York: John Wiley & Sons.
3. Clayton, D. & Hills, M. (2013). *Statistical methods in epidemiology*. Oxford University Press.

STAT-7112 **Analysis of Clinical Trials** 3(3-0)

Clinical trials are experiments designed to evaluate new interventions to prevent or treat disease in humans. The interventions evaluated can be drugs, devices, surgeries, behavioral interventions, community health programs or health delivery systems. The course will explain the basic principles for design of randomized clinical trials and how they should be reported. The first part of the course contains terminology used in clinical trials and several common designs used for clinical trials, such as parallel and cross-over designs. The second half of the course, includes how clinical trials are analyzed and interpreted. Finally, the course reviewed the essential ethical consideration involved in conducting experiments on people. The aim of this course is to impart knowledge about clinical trials and existence of bias and random error of clinical studies occurred during the conduction of clinical trials. This course deals with different types of data management and case report forms. The course provides the mathematical and conceptual formation of cross-over design, longitudinal and factorial designs utilized for both single stage and multi-stage phase II trials. Course also enlightens the mathematical strategies of categorical outcomes of phase I – III trials.

Contents

1. Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies
2. Conduct of clinical trials, overview of Phase I-IV trials
3. Multi-center trials
4. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.
5. Design of clinical trials: parallel vs. cross-over designs
6. Cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials
7. Sesign of Phase I trials, design of single-stage and multi-stage
8. Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials.
9. Reporting and analysis
10. Analysis of categorical outcomes from phase I - III trials
11. Analysis of survival data from clinical trials.
12. Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data
13. Meta-analysis of clinical trials.

Recommended Texts

1. Marubeni, E. & Valsecchi, G. (2004). *Analyzing survival data from clinical trials and observational studies*. New York: John Wiley & Sons.
2. Jennison, C. & Turnbull., B. (1999). *Group sequential methods with applications to clinical trails*. CRC Press.

Suggested Readings

1. Friedman, L., Furburg, C., &Demets, D. (1998). *Fundamentals of clinical trials*. USA: Springer.
2. Fleiss, J. (1989). *The design and analysis of clinical experiments*. New York: John Wiley & Sons.
3. Piantadosi, S. (1997). *Clinical trials: A methodological perspective*. New York: John Wiley & Sons.

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STAT-7113 **Survival Data Analysis** **3(3-0)**

This course will provide an introduction to the principles and methods for the analysis of time-to-event data. This type of data occurs extensively in both observational and experimental biomedical and public health studies, as well as in industrial applications. The course is designed to analyze data from studies in which individuals are followed up until a particular event occurs - e.g. death, cure, relapse - making use of follow-up data for those who do not experience the event, with proper attention to underlying assumptions and a major emphasis on the practical interpretation and communication of results. The content includes: Kaplan-Meier life tables; log rank test to compare two or more groups; Cox's proportional hazards regression model; checking the proportional hazards assumption; time-dependent covariates; multiple or recurrent events; and sample-size calculations for survival studies. Main objective of the course are, To identify characteristics of survival data and their implications for analysis, to compare groups using common statistical procedures, to analyze survival data and interpret results using Cox proportional hazards model, to assess models for fulfillment of proportional hazards & other aspects of model adequacy to analyze survival data and interpret results using parametric regression models.

Contents

1. Multiparameter analysis using large sample
2. Likelihood methods for response time data.
3. Survival function
4. Hazard function
5. Multipara meter models
6. Parameterization and regression-type models
7. Likelihood functions for censored data.
8. Kaplan-Meier (Product-limit) estimation
9. Testing based on maximum likelihood estimators
10. Likelihood ratios
11. Score tests.
12. Computational methods including the EM.
13. Algorithms
14. Partial likelihood methods for proportional hazards
15. Analysis of grouped data.

Recommended Texts

1. Collet, D. (2003). *Modeling survival data in medical research.* London: Chapman and Hall.
2. Hosmer, D. &Lemeshow, S. (1999). *Applied survival analysis: regression modeling of time to event data.* New York: John Wiley & Sons.

Suggested Readings

1. Lee, E. T. (2013). *Statistical methods for survival data analysis.* New York: John Wiley & Sons.
2. Lawless, J. F. (1982). *Statistical models and methods for lifetime data.* New York: John Wiley & Sons.
3. Bain, L. J. (1978). *Statistical analysis of reliability and life-testing models.* Marcel Dekker.

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STAT-7114 **Logical Reasoning and Research Methods** **3(3-0)**

Logical reasoning is the process of using a rationale, systematic, series of steps based on sound mathematical procedures and given statements to arrive at a conclusion. Logical thinking skills are important because they can help reason through important decisions, solve problems, generate creative ideas and set goals- all of which are necessary for developing the career. The aim of this course is to develop comprehensive understanding of propositions and arguments those are highly utilized in the statistical decision making strategies and the suitable terminologies of term validity and truth tables. This course imparts the knowledge of preparation of research design and necessary components related to research design. It deals with the data collection methods, sampling techniques and their designs and preparation of a research report. It consists of different case studies based on logical reasoning. Multidimensional scaling, preparation of research design, questionnaire and interview methods are also the part of the course. The course focuses on science and scientific attitude, theory and facts and formulation of research problems.

Contents

1. Propositions and arguments
2. Recognizing arguments
3. Validity and invalidity
4. Fallacies
5. Symbolizing arguments
6. Truth functions, truth tables
7. Proving validity and invalidity.
8. Science and scientific attitude, theory and fact
9. Sources and properties of hypothesis, formulation of research problems and its significance.
10. Preparation of research design, components of research design,
11. Questionnaires and interviews
12. Schedules and their constructions.
13. Data Collection methods.
14. Sampling techniques and their designs
15. Preparation of research report.
16. Multidimensional scaling
17. Dissemination of reports
18. Case Studies

Recommended Texts

1. Somekh, B. & Lewin, C. (2011). *Theory and methods in social research*: McGraw Hill.
2. Copi, I. M., Cohen, C. &McMohan, K. (2014). *Introduction to logic* (14th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Hurley, P. J. (2011). *A concise introduction to logic* (3rd ed.). Wad Worth Publishing Co.

STAT-7115 **Analysis of Repeated Measures** **3(3-0)**

Repeated measure design is a research design in which subjects are measured two or more times on the dependent variable. Repeated measure ANOVA compares means across one or more variables that are based on repeated observations. A repeated measure ANOVA model can also include zero or more independent variables. Repeated measures designs are very important branch of design and analysis of experiments. These designs are useful for analyzing numerical results obtained under repetitive experiments over the same subject over the time. Repeated measures design aims to evaluate the effect of variability between groups under subjects are used throughout the experiment. Repeated measures designs can be very powerful because they control for factors that cause variability between subjects. This course consists of advance techniques for analyzing repeated measures such as Multifactor repeated measures designs and statistical power measuring sequential effect. The course deals with the introduction of repeated measures designs, models and assumptions, test of trend analysis, models with interactions and applications of repeated measure designs. It also includes multi factor experiments in repeated measure designs, two and three factors experiments with repeated measures. Measures of association and statistical power in multifactor repeated measure designs are also the part of the contents.

Contents

1. Introduction of repeated measures designs
2. Models and assumptions, variants- covariance structure, box's correction
3. Huynh-Feldt (HF) condition
4. Circularity assumption
5. Necessary and sufficient conditions for circularity
6. Mauchley sphere city test, trend analysis.
7. Test of trend analysis
8. Models with interaction
9. Measures of association and power in univariate repeated measure design, application of repeated measure in basic design and analysis of co-variance.
10. Multi factor experiments in repeated measure designs
11. two factors experiment with one factor repeated measure
12. Three factor experiments with repeated measure
13. Controlling sequence effect
14. Unequal group size.
15. Measures of association
16. Statistical power in multifactor repeated measure designs.

Recommended Texts

1. Montgomery, D.C. (2001). *Design and analysis of experiment*. New York: John Wiley & Sons.
2. Stevens, J. (1996). *Applied multivariate statistics for the social sciences.* (3rd ed.). New Jersey: Lawrence Erlbaum Associates.

Suggested Readings

1. Weinfurt, K. P. (1995). *Repeated measure analysis*. In L.G. Grimm.
2. Cochran, W. G., & Cox, G. M. (1992). *Experimental designs*. New York: John Wiley and Sons.

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STAT-7116 **Applied Logistic Regression** **3(3-0)**

Logistic regression is the appropriate regression analysis to conduct when the dependent variable is dichotomous. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval, or ratio level independent variables. Logistic model is used to model the probability of a certain class or event existing such as pass/fail, win/lose, alive/dead, or healthy/sick. Given a certain factor, logistic regression is used to predict an outcome which has two values such as 0 or 1. Logistic regression is a predictive modeling algorithm that is used when the Y variable is binary categorical. This course introduces the regression methods for analyzing data based on nominal and ordinal scale response. This course highlights both the theoretical and the mathematical derivations of Non-iterative weighted and discriminant functional analysis method. Course focuses on techniques for estimating dichotomous polytomous and continuous variables. Model-building strategies and methods of estimating logistic regression methods are also defined of various types. The goal is to help the students to develop a solid theoretical background in cohort studies, case studies and matched case studies.

Contents

1. Concept of simple regression and Logistic regression
2. Fitting simple and multiple Logistic Regression (LR)
3. Models using MLE
4. Weighted Least Squares
5. Non-iterative weighted Least Squares
6. Discriminant functional analysis methods
7. Dichotomous variables
8. Polytomous
9. Continuous Independent Variables.
10. Multivariate Case
11. Interaction
12. Confounding,
13. Estimation of odds ratios in the presence of interaction.
14. Model-building Strategies
15. Methods for Logistics Regression.
16. Application of Logistic Regression with different sampling methods
17. Cohort studies
18. Case studies and matched case studies.

Recommended Texts

1. Jiang, J. (2007). *Linear and generalized linear mixed models and their applications*. USA: Springer.
2. Lindsey, J. K. (1997). *Applying generalized linear models*. New York: Springer.

Suggested Readings

1. McCullagh, P. & Nelder, J. A. (1989). *Generalized linear model* (2nd ed.). London: Chapman and Hall.
2. Hosmer, D. W. &Hemeshow (1989). *Applied logistic regression*. New York: John Wiley & Sons.
3. Cox, D. R. & Oakes, D. (1984). *Analysis of survival data*. London: Chapman and Hall.

STAT-7117 **Bayesian Decision Theory** 3(3-0)

Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment. Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision-making process. This course introduces the Bayesian approach to statistics in decision theory, starting with the concept of probability and moving to the analysis of data. We will learn about the philosophy of the Bayesian approach as well as how to implement it for common types of data. The main aim of this course is to provide a strong mathematical and conceptual foundation in the methods of Bayesian Decision Theory, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the estimation of parameters in different approach. Prior distribution, formulation of posterior distribution and predictive distribution estimation is part of the content.It deals with the utility theory, loss function and development of the loss function from the utility theory. It also discusses the Bayes estimators and Bayes predictors under different distribution. Risk, Types of risk and choice of a sample size under posterior Bayes risk is part of the content.

Contents

1. Utility theory; The utility of money
2. Rewards
3. Consequences
4. The loss functions
5. Development of the loss function from the utility theory
6. Certain standard loss functions for inference
7. Predictive problems
8. Bayes estimators
9. Bayes predictors
10. Bayesian hypothesis testing under the different loss functions.
11. Decision function
12. Multivariate loss functions with Bayesian estimation.
13. Risk; Types of risk
14. Choice of a sample size under posterior Bayes risk.

Recommended Texts

1. Robert, C. P. (2007). *The bayesian choice: A decision theoretic motivation* (2nd ed.). New York: Springer.
2. Berger, J.O. (1985). *Statistical Decision Theory and Bayesian Analysis*. Springer-Verlag, New York.

Suggested Readings

1. West, M. and Harrison, J. (1997). *Bayesian Forecasting and Dynamic Models*. (2nd ed.). Springer-Verlag, New York.
2. Hagan A. (1994). *Kendall's Advanced Theory of Statistics*, (V2B) Bayesian Inference. University Press: Cambridge.
3. Black-well and Grishick, M. A. (1996). *Theory of Games and Statistics Decisions*. New York: John Wiley & Sons.

STAT-7118 **Advanced Operations Research** **3(3-0)**

Operational Research is the application of scientific methods to the study of complex organizational problems. It is concerned with applying advanced analytical methods to make effective decisions in strategic planning or operational planning, and build more productive systems. This includes all key stages of solving real-world problems.Operational researchers and statisticians play a fundamental role in the modern world. Operations Research (OR) is a discipline that helps to make better decisions in complex scenarios by the application of a set of advanced analytical methods. Research by providing quality and effective educational programs to achieve the ambitions of the development plans of the society, with continued efforts at improving these programs and maintaining the quality of scientific research. Prescribed course covers the knowledge related to Statistics in the concern of advanced operations research. Course aimed at special techniques based on maximal flow model. PERT and critical path method. Course also enlightens the quadratic programming. wolfe's method and its applications in different fields of marketing. The course is designed to fulfill the needs of society in the fields of Statistics and Operations and to understand different application areas of operations research like separable convex programming, network analysis and non-linear programming techniques.

Contents

1. Linear programming: simplex algorithm
2. Sensitivity analysis, duality theory.
3. Network analysis: shortest route problem, minimal spanning tree algorithm
4. Maximal flow model
5. PERT, critical path method (CPM)
6. Integer Programming: the branch and bound technique, functions with N possible values.
7. Non-linear programming techniques.
8. Quadratic programming
9. Wolfe's method
10. Beale's method, separable convex programming
11. Piece-wise linear programming.
12. Queuing theory
13. Sequencing.
14. Inventory management
15. Inventory control and techniques
16. Some advanced topics in programming.

Recommended Texts

1. Taha, H. A. (2002). *Operations Research*. London: Prentice Hall.
2. Krajewski, L. J. & Ritzman, L.P. (2001). *Operations management: strategy and analysis*. London: Prentice Hall.

Suggested Readings

1. Bhatti, S. A. & Bhatti, N. A. (1998). *Operations research, an introduction*. Publisher: A-one publisher.
2. Hillier, F., & Lieberman, G. (1998). *Introduction to operations research*. London: McMillan.
3. Gupta, P. K. & Hira, D. S. (1994). *Operations research*. New Dehli: S. Chand and Co.

STAT-7119 **Numerical Analysis and Stochastic Simulation** **3(3-0)**

To explore complex systems, physicists, engineers, financiers and mathematicians require computational methods since mathematical models are only rarely solvable algebraically. Numerical methods, based upon sound computational mathematics, are the basic algorithms underpinning computer predictions in modern systems science. This course is designed for the students of M.Phil. in Statistics. The field of advanced simulation contains powerful tools and techniques to study stochastic models and other objects which defy a direct mathematical analysis. This course gives a broad treatment of the important aspects of stochastic simulation and its applications to e.g. queuing. reliability, manufacturing, risk analysis, and financial models. Aside from the fundamental mathematical interests, this course is thus also recommended for students wishing to make a career in business. finance. operations research, etc. At the end of the course students will be able to demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. Apply numerical methods to obtain approximate solutions to mathematical problems. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations. Analyze and evaluate the accuracy of common numerical methods.

Contents

1. Error analysis
2. Bazier and B Spline curves.
3. Guassian Quadrature
4. Adaptive integrators,
5. Multiple integration.
6. Cubic splines, Boundary value problem.
7. Numerical solution of partial differential equations
8. Approximation of function.
9. Stochastic simulation
10. Generating uniform random variables
11. Partial and general methods for non-uniform random variables
12. Testing random numbers.
13. Building simulation models
14. Variance reduction techniques.
15. Statistical validation techniques

Recommended Texts

1. Toral, R. & Colet, P. (2014). *Stochastic numerical methods: An introduction for students and scientists.* New York: John Wiley & Sons.
2. Ross, S. M. (2002). *Simulation* (3rd ed.). Academic Press
3. Crawley, M. J. (2012). *The R book* (2nd ed.).New York: John Wiley & Sons.

Suggested Readings

1. Velten, K. (2009). *Mathematical modeling and simulation.* New York: John Wiley & Sons.
2. Vasishth, S. & Bore, M. (2010). *The foundations of statistics: A simulation-based approach.* USA: Springer.
3. Morgan, B. J. T. (1984). *Elements of simulation.* UK: Chapman and Hall.

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STAT-7120 **Mixture Distributions** **3(3-0)**

A mixture distribution is the probability distribution of a random variable that is derived from a collection of others random variables as follows first a random variable is selected by chance from the collection or according to given probabilities of selection and then the value of the selected random variable is realized. Mixture distribution is a useful way to show how variables can be differentially distributed. Mixture distribution is able to capture a wide variety of complex distribution, these distributions are particularly applicable to situations when the quantity is determined by two stage experiments, 1st a mixture component is chosen and then the value is determined from the appropriate mixture component. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of mixture distribution, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the estimation of mixing parameters: graphical methods, method of moments, maximum likelihood, Bayesian, minimum distance of distribution functions, minimum distance of transforms and numerical decomposition of mixtures. It also discusses modality: structure and assessment, sequential problems and procedures: unsupervised learning problems.

Contents

1. Statistical Applications, Mathematical aspects of mixture distributions.
2. Identifiability
3. Multimodality
4. Negative mixing weights
5. General properties of distributions.
6. Estimating mixing parameters
7. Graphical methods
8. Method of moments
9. Maximum likelihood
10. Bayesian, minimum distance of distribution functions, minimum distance of transforms and numerical decomposition of mixtures.
11. Determining number of components of a mixture. Informal techniques, formal techniques for special cases and general formal techniques.
12. Modality: structure and assessment
13. Sequential problems and procedures
14. Unsupervised learning problems
15. Approximate solutions for: mixing parameters, component distribution parameters.
16. Mixing and component parameters for dynamic linear models.

Recommended Texts

1. Geoffrey, J. M. & David, P. (2001). *Finite mixture models.* New York: John Wiley & Sons.
2. Bruce, L. (1995). *Mixtures models: Theory, geometry and applications.* Institute of Mathematical Statistics.

Suggested Readings

1. Ferguson, T.S. (1967). *Mathematical statistics: A decision theoretic approach.* Academic Press.
2. Titterington, D. M., Smith, A. F. H. & Markov, U. E. (1986). *Statistical analysis of finite mixture distributions.* New York: John Wiley & Sons.
3. Everitt, B. S. & Hand, D. J. (1981). *Finite mixture distributions.* UK: Chapman & Hall.

STAT-7121 **Mathematical Demography** **3(3-0)**

Demography is the study of statistics such as births, death, income or the incident of disease which illustrates the changing structure of the human population. Demography is defined as the composition of a particular human population. Mathematical demography is the subfield of demography that is concerned with developing and refining measures and methods for studying population compositions and change. Sample data is known commonly used by demographer and statistical methods are commonly used in conjunctions with mathematical methods. The main objective of this subject is to reported significant advances in methods of population analysis. conceptual and mathematical theories of demographic dynamics and behavior, and the use of these theories and methods to extend scientific knowledge and to inform policy and practice. Create awareness about population matters, environment, and supply and demand of essential commodities. The course also includes life tables, that is a table which shows for each age what the probability is that a person of that age will die. Langrage estimates projections by application of the straight line. logistic, exponential and polynomial curve are also the part of course. The course focuses on the development and applications of population growth models and estimation of age.

Contents

1. Population Growth Models, Development and Application of Lotka Integral Equation
2. Smoothing of age data by various methods,
3. Estimations of age at first marriage,
4. Child mortality
5. Adult mortality
6. Fertility rate
7. Gross reproduction rate
8. Net reproduction rate
9. Life tables
10. Construction of abridged life tables and decrement life tables,
11. Lagrange estimates
12. Projections by application of straight line, logistic
13. Exponential curves
14. Gumpertz and Polynomial curves
15. Component method
16. Path Analysis for decomposition of effect of factors affecting and dependent variable.

Recommended Texts

1. Preston, S. H., Patrick, H. & Michel, G. (2001). *Demography: Measuring and modeling population process*. Oxford: Blackwell Publishers.
2. Nathan, K. &Cawell, H. (2004). *Applied mathematical demography.* USA: Springer.

Suggested Readings

1. Shryok H. & Seigal J. S. (1994). *The methods and materials of demography.* (Condensed ed.). New York.
2. Feotal, U. N. (1954). *Infant, and early childhood mortality* (Vol. I & II). USA: Series A, Population Studies No. XIII. Population Division, New.
3. Coale, A. and Demeny, P. (1966). *Regional model life tables and stable populations*. Princeton University Press.

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STAT-7122 **Multi-level Modeling** 3(3-0)

Multilevel models are statistical models of parameters that vary at more than one level. An example could be a model of student's performance that contains measures for individual students as well as measures for classrooms within which the students are grouped. Multilevel modeling is an approach that can be used to handle clustered or group data multilevel modeling provides a useful framework for thinking about problems with this type of hierarchical structure. Multilevel recognize the existence of such data hierarchies by allowing for residual components at each level of the hierarchy. Course also signifies the relative efficiency of multilevel modeling strategies instead of traditional regression analysis and estimation of two and multilevel parameters and the brief interpretation of the parameters. Course imparts the advance knowledge of the effect of sample size on the properties of the multilevel model estimates and applications of multilevel models to overcome the real life applications. The course focuses on the scope of multilevel models in various fields and estimation of parameters in multilevel models. Sample size estimation for multilevel models and effect of sample size on the properties of multilevel model estimates are also the part of the contents.

Contents

1. Introduction to multilevel modeling,
2. Scope of multilevel models in various fields
3. Traditional regression models
4. Comparison of multilevel models with traditional regression models
5. Two level random effect multilevel models and interpretation of parameters
6. Techniques of estimations
7. Estimation of parameters
8. Estimation of parameters in multilevel models
9. Intra-class correlation
10. Concept of intra-class correlation in multilevel (ML) models
11. Fitting multilevel models
12. Criteria for the goodness of the ML models
13. Sample size estimation for ML models
14. Effect of sample size on the properties of multilevel model estimates
15. Efficiency of estimates
16. Application of multilevel models (using statistical packages such as MLwin or HLM)
17. Case studies

Recommended Texts

1. Anthony, S., &Stephes, W. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Sage publication Inc.
2. Goldstein, H. (2010). *Multilevel statistical models* (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Goldstein, H. (1995). *Multilevel statistical models* (2nd ed.). New York: John Wiley & Sons.
2. Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). Routledge Publisher.
3. Kreft, I., & De Leeuus, J. (1998). *Introducing multilevel modeling thousand oaks*. Sage Publication Inc.

STAT-7123 **Bayesian Analysis** **3(3-0)**

This course introduces the Bayesian approach to statistics, starting with the concept of probability and moving to the analysis of data. It deals with the philosophy of the Bayesian approach as well as how to implement it for common types of data. In particular, the Bayesian approach allows for better accounting of uncertainty, results that has more intuitive and interpretable meaning, and more explicit statements of assumption. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of Bayesian statistics, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Bayesian procedures are concerned with the best estimating a value or range of values for a particular population parameter. It deals with the estimation of parameters in different approach. It also discuss the paramcter estimation of different probability distributions and their efficiency. Prior distribution, formulation of posterior distribution and predictive distribution estimation is part of the content. Completion of this course will give an understanding of the concepts of the Bayesian approach, understanding the key differences between Bayesian and Frequentist approaches, and the ability to do basic data analyses.

Contents

1. Formulation of a decision problem
2. Randomized and non-randomized decision rules,
3. Benefits of Bayesian statistics
4. Comparison of Bayesian statistics
5. Classical statistics
6. Prior Distribution
7. Posterior Distribution.
8. Risk function, optimality of decision rules.
9. Utility theory
10. Loss function.
11. Subjective probability
12. Selection of prior distribution for Bayesian analysis.
13. Bayesian analysis for statistical inference problems of estimation
14. Testing hypotheses
15. Confidence interval and prediction.
16. Bayesian decision theory.
17. Admissible and minimax decision rules.
18. Complete class of decision rules.

Recommended Texts

1. Bolstad, W.M. (2013). *Introduction to bayesian statistics*. New York: John Wiley & Sons.
2. James. O. B. (2013). *Statistical decision theory and bayesian analysis* (2nd ed.). USA: Springer.

Suggested Readings

1. De Groot, M. H. (2004). *Optimal statistical decisions*. New York: John Wiley & Sons.
2. Ferguson, T.S. (1967). *Mathematical statistics: A decision theoretic approach*. USA: Academic Press.
3. Carlin, B.P. & Louis, T.A. (2008). *Bayesian method for data analysis*. New York: Chapman & Hall, CRC press.

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STAT-7124 **Generalized Linear Models** **3(3-0)**

This course deals with statistical models for the analysis of quantitative and qualitative data. The statistical methods studied are the general linear model for quantitative responses (including multiple regression, analysis of variance and analysis of covariance), regression models for binary data (including logistic regression and probit models), models for count data (including Poisson regression and negative binomial models) models for continuous and positively skewed data (Gamma regression and Inverse Gaussian regression models. The course will be a mix of theory, computing and data analysis, depending on the student's background. The course aims to give more emphasis on statistical modelling. Starting from the linear regression framework, results and techniques in the field of generalized linear models will be developed. This course is based on the theory in exploratory data analysis and further in statistical modelling. Upon successful completion, students will have the knowledge and skills to: Communicate the role of generalized linear modelling techniques (GLMs) in modern applied statistics and implement the methodology and explain the underlying assumptions for GLMs and perform diagnostic checks whilst identifying potential problems and Performing statistical analysis using statistical software, incorporating underlying theory and methodologies.

Contents

1. Introduction: background, review of linear models in matrix notation, model assessment, some pre-required knowledge
2. The exponential family of distributions: Definition and examples. Mean and variance, variance function and scale parameter.
3. Generalized linear models (GLM): linear predictor, link function, canonical links, Assumptions of the GLM, maximum likelihood estimation, iterative reweighted least squares and Fisher scoring algorithms, the significance of parameter estimates, deviance, Pearson and deviance residuals
4. Pearsons chi-square test and the likelihood ratio test, Wald test.
5. Binary and Binomial data analysis: distribution and models, logistic regression models, odds ratio
6. One- and two-way logistic regression analysis.
7. GLM for Counts data analysis: Poisson regression
8. Negative binomial regression estimation and inferences
9. GLM for continuous response models: Gamma and Inverse Gaussian response models, estimation and inferences.
10. Residual Analysis in the GLM
11. GLM estimation with different statistical software

Recommended Texts

1. Agresti, A. (2015). Foundations of linear and generalized linear models. New York: John Wiley & Sons.
2. McCullegh P. & Nelder J.A. (1990). Generalized linear models. NEW York: Chapman and Hall.
3. Hardin, J.W. &Hilbe, J.M. (2012). Generalized linear models and extensions (3rd ed.). Stata Press Publication.

Suggested Readings

1. Myers, R. H., Montgomery, D. C., Vining, G.G. & Robinson, T. J. (2010). Generalized linear models with applications in engineering and the sciences (2nd ed.). New York: John Wiley & Sons.
2. Annette, J. D. (2001). An introduction to generalized linear models. Text in Statistical Science.

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STAT-7125 **Statistical Machine Learning** **3(3-0)**

Statistical Machine Learning typically covers a range of topics that span from foundational concepts to advanced techniques. The term "statistical" in the title reflects the emphasis on statistical theory and methodology. The course combines methodology with theoretical foundations. Theorems are presented together with practical aspects of methodology and intuition to help students develop tools for selecting appropriate methods and approaches to problems in their own research. The course includes topics in statistical theory that are important for researchers in machine learning, including non-parametric theory, consistency, minimax estimation, and concentration of measure.

Contents

1. Review of statistics and probability, (bias/variance, mle, regression, classification)
2. Introduction to machine Learning, types of machine learning
3. Supervised Learning (a) Linear Regression: low dimensional, ridge regression, lasso, greedy regression (b) Non-parametric Regression: kernel regression, local polynomials, additive, RKHS regression (c) Linear Classification: linear, logistic, SVM, sparse logistic (d) Non-parametric Classification: Nearest Neighbor, Naive Bayes, plug-in, kernelized SVM (e) Conformal Prediction (f) Cross Validation
4. Unsupervised Learning (a) Non-par Density Estimation (b) Clustering: k-means, mixtures, single-linkage, density clustering, spectral clustering (c) Measures of Dependence (d) Graphical Models: correlation graphs, partial correlation graphs,
5. Model Evaluation and Selection: Cross-Validation Bias-Variance Tradeoff, Performance Metrics (Accuracy, Precision, Recall, F1 Score, ROC Curve)
6. Other Topics (a) Nonparametric Bayesian Inference (b) Bootstrap and subsampling (c) Interactive Data Analysis (d) Robustness (e) Active Learning (f) Differential Privacy (g) Deep Learning (h) Distributed Learning (i) Streaming

Recommended Books

1. C. Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
2. Hastie, R. Tibshirani, J Friedman, Elements of Statistical Learning, Springer, 2009.
3. K. Murphy, Machine Learning: a Probabilistic Perspective, MIT Press, 2012.

Suggested Readings

1. B. D. Ripley, Pattern Recognition and Neural Networks, Cambridge University Press, 1996.
2. G. James, D. Witten, T. Hastie, R. Tibshirani, An Introduction to Statistical Learning, Springer, 2013.

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STAT-7126 **Non-Linear Estimation** **3(3-0)**

Nonlinearity is a relation between data points that cannot be condensed into a neat linear graph. Nonlinear modeling is empirical or semi-empirical modeling which takes at least some nonlinearity into account. The reason to use the nonlinear models is because the relationships between the dependent and independent parameters are not linear. Nonlinear models are widely used in many applications such as in dose response studies conducted in agricultural sciences, toxicology and other biological sciences. Nonlinear estimation involves the fitting of nonlinear models by least square. This course introduces some non-linear statistical models, their parameter's estimation and some stability transformations of the variables. This course emphasizes both the theoretical and practical aspects of statistical non-linear estimation and analysis. This course also signifies the applications of non-linear modeling and importance of rare events adopted methods like kernel smoothing, additive methods and unweighted least square methods. Course also enlightens the practical applications of the minimum risk estimates and minimax deviation methods. Analysis of the non-linear models and their comparisons will be evaluated by using computational techniques and through statistical software.

Contents

1. Models: Linear and non-linear models, their importance
2. Parameters and estimation using ML method
3. Comparisons of different methods
4. Transformations of parameters, inference
5. Different transformations
6. Stable transformations
7. Computing Methods for Non-linear Modelling
8. Confidence intervals for parameters and functions.
9. Applications of non-linear Modelling
10. Smoothing techniques
11. Kernal smoothing methods
12. Additive methods
13. Unweighted least square method
14. Bayesian estimation.
15. Minimum risk estimate
16. Minimax deviation method
17. Projection and its types
18. Projection method with bounded parameters.

Recommended Texts

1. Seber, G. A. F. & Wild, C. J. (2003). *Non-linear regression*. New York: John Wiley & Sons.
2. Ross, G. J. S., (1990). *Non-linear estimation*. New York Springer.

Suggested Readings

1. Kotz, S. & Johnson, N. (1985). *Encyclopedia of statistical sciences (Non-linear Models, Non-Linear Regression)*. New York: John Wiley & Sons.
2. Ralkowsky, D. A. (1984). *Non-linear regression modelling*. New York: Dekker.
3. Bard, Y. (1974). *Non-linear parametric estimation*. New York: Academic Press.

STAT-7127 **Statistical Process Control** **3(3-0)**

The use of statistical techniques to control a process or production method and activities which monitors a process in real-time to prevent defects while a lot is being manufactured are known as statistical process control. SPC tools and procedures can help to monitor process behavior, discover issues in internal systems, and find solutions for production issues. This helps to ensure that the process operates efficiently, producing more specification-conforming products with less waste. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical process control, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. This course is designed for providing applicable knowledge of different control charts, EWMA and CUSUM charts, process capability study and process monitoring. The course deals with the construction of control charts for monitoring location and dispersion parameters under univariate and multivariate setups. It also discusses the performance measures, such as average run length and the probability of detection, of the control charts. This covers the process capability analysis, process improvements using design of experiments and Taguchy method. Acceptance sampling plans along with the different ISO series are part of the contents.

Contents

1. Introduction to statistical process control and its tools
2. Univariate EWMA control charts
3. Univariate CUSUM control charts
4. Multivariate process monitoring through Hotelling T^2 charts.
5. Chi-square chart
6. Generalized variance chart.
7. Multivariate EWMA and CUSUM charts.
8. Robustness approaches for process monitoring
9. Nonparametric approaches for process monitoring
10. Some Bayesian structures for quality control,
11. Covariates and process improvement
12. Process capability study, Introduction of six sigma
13. Designed experiment and process monitoring
14. Acceptance sampling and acceptance sampling plans.
15. Advancements in techniques for quality improvement
16. Taghuchi's methods for quality control, Evolutionary operation and process improvement
17. Introduction to statistical software's for SPC.

Recommended Texts

1. Montgomery, D.C., (2013). *Introduction to Statistical Quality Control*. (9th ed.). John Wiley & Sons.
2. Qiu, P. (2013). *Introduction to Statistical Process Control,* (1st ed.). Taylor and Francis, New York.
3. Oakland, J.S., (2007). *Statistical Process Control*. (6th ed.), Butterworth-Heinemann. Elsevier Science Publisher.

Suggested Readings

1. Alwan, L.C., (2000). *Statistical process analysis*. McGraw-Hill.
2. Farnum, N.R. (1994). *Statistical quality control and improvement*. Duxbury

STAT-7128 **Time Series Analysis** **3(3-0)**

Time series analysis is used in order to understand the underlying structure and function that produce the observations. Time series refer to any group of statistical information collected at regular intervals of time. Time series analysis is used to detect the changes in patterns in these collected data. Forecasting and predicting for the future is a key factor in planning and development of any organization in this running world. As now, world has become a global village so our market has become much advance as compared to previous decades. Now the market demand is to plan for future based on existing and previous knowledge. In this condition empirical evidences are of much importance. It deals with the method of data collection, description measures of data for interpretation of results, model selection, decision making and Forecasting. This course is designed for the advance modelling and forecasting of time series data. This focuses on advancing time series techniques and forecasting methods. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.

Contents

1. Types of data, components of time series data
2. Stochastic processes
3. Stationary and non-stationary processes
4. Forms and tests of nonstationarity.
5. Purely random processes
6. Random walk models
7. Lag operator, Difference equations and their solutions
8. Smoothing and decomposition methods.
9. Univariate time series analysis (ARMA, ARIMA, Box-Jenkins approach, ARCH, GARCH etc.).
10. Time series modeling and diagnostic checking
11. State space models
12. Use of Kalman filter.
13. Multivariate time series analysis: Granger causality
14. Vector Autoregressive Models.
15. Transfer function and intervention analysis
16. Time series forecasting, Co-integration analysis
17. Vector error correction model and Johansen approach.

Recommended Texts

1. Asteriou, D. (2006). *Applied econometrics.* New York: Palgrave Macmillan.
2. Anderson, T. (1976). *The statistical analysis of time-series.* New York: John Wiley & Sons.

Suggested Readings

1. Box, G.E.P. & Jenkins, G.M. (1994). *Time-series analysis: Forecasting and control* (3rd ed.). USA: Prentice Hall, Englewood Cliffs.
2. Chatfield, C. (2003). *The analysis of time series-An introduction.* New York: Tylor & Francis.
3. Enders, W. (1995). *Applied econometric time series.* New York: John Wiley & Sons

STAT-7129 **Spatial Data Analysis** **3(3-0)**

Spatial data refers to the shape, size and location of the feature. Spatial analysis is a process in which our model problems geographically, derive results by computer processing, and then explore and examine those results. Spatial analysis allows to solve complex location-oriented problems and to better understand where and what is occurring in the world. It goes beyond mere mapping to study the characteristics of places and the relationships between them. Spatial analysis lends new perspectives to decision making. The spatial statistics toolbox contain statistical tools for analyzing spatial distribution, processes, patterns and relationships. Spatial statistics include any of the formal techniques which study entities using their topological, geometric or geographic properties. The main objective of this course is to introduce spatial statistics and conceptual foundation of big data handling, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with Eigen function analysis of aerial unit configuration, spatial auto-correlation and spectral analysis. It also discusses the relationship between autoregressive terms. Spectral models Kriging are part of the content. The course focuses on data handling, Eigen function analysis and higher order autoregressive models.

Contents

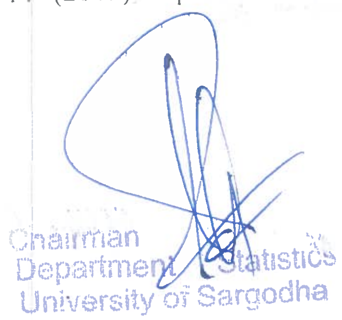
1. Introduction to Spatial data, Types of Data, Basic Properties, Preliminary Concepts (Spatial Structures and Modeling), Objectives and Applications
2. Spatial processes, Classical methods used for Prediction and interpolation of spatial processes.
3. Characterizing spatial process: the Assumption of stationary in spatial process.
4. Estimation and modeling of spatial correlations: Estimating variogram.
5. Fitting parametric models: Matern family of covariance models.
6. Generalized linear models for geostatistical data: poisson linear model, Binomial logistics linear model, spatial survival analysis and Cox Processes.
7. Parameter estimation: Maximum likelihood estimation and restricted maximum likelihood estimation.
8. Point pattern analysis
9. Spatial Autocorrelation: SAR and CAR, Geographically Weighted Regression Techniques
10. Buffering, proximity and neighborhood functions
11. Polylines and network Analyses
12. Area objects and types of area objects, Geometric properties of areas
13. Multivariate spatial data handling
14. New approaches to spatial analysis

Recommended Texts

1. Cressie, N. (2015). *Statistics of spatial data, revised edition.* New York: John Wiley & Sons.
2. Diggle P. J. (2006). Model-Based Geostatistics, Springer.
3. Le N.D. and Zidek J.V. (2006), Statistical Analysis of Environmental Space-Time Processes. Springer.
4. Webster R. and M.A. Oliver (2007), Geostatistics for environmental scientists. 2nd edition, John wiley& sons Ltd.

Suggested Readings

1. Banerjee S., Carlin B. P. and Gelfand A.E. (2004). Hierarchical Modeling and Analysis for Spatial Data. Chapman and Hall.
2. Haining R. P. (2003). Spatial Data Analysis: theory and practice. University Press. Cambridge



STAT-7130 **Analysis of Multi-Factor Designs** **3(3-0)**

The course will examine how to design experiments, carry them out, and analyze the data they yield. Various designs are discussed and their respective differences, advantages, and disadvantages are noted. In particular, factorial and fractional factorial designs are discussed in greater detail. The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. Both designs and statistical analysis issues are discussed. Particular attention will be paid to: understanding the process of designing an experiment including factorial and fractional factorial designs; examining how a factorial design allows cost reduction, increases efficiency of experimentation, and reveals the essential nature of a process. This course aims how to manage factorial experiments, how to analyze these experiments under limited resources and material by providing a wide range of information about the concept of blocking and controlling features of designs. This course is composed of different resolution of design, replicated design, response surface methodology, steepest methods and advance robust designs like cross arrayed designs and Taguchi methods.

Contents

1. A review and analysis with unequal subclass numbers, 2n, 3n and mixed factorial experiments
2. Blocking factorial design
3. Estimation of model parameters
4. Fractional replication and alias structure
5. Resolution III, IV and V design.
6. Unreplicated factorial designs
7. Lenth's method
8. Danial method
9. Series of experiments in time and space
10. Response surfaces methods (RSM)
11. Analysis of Response surfaces methods (RSM)/designs, 1st order and 2nd order model. Method of steepest ascent
12. Blocking in RSM. Saturated designs and their analysis.
13. Nested Designs: two stage and general-m stage
14. Robust designs
15. Taguchi methods.

Recommended Texts

1. Montgomery, D. C. (2012). *Design and analysis of experiments* (8th ed.). New York: John Wiley & Sons.
2. Boniface, D. R. (1995). *Experimental design and statistical methods*. Chapman and Hall.

Suggested Readings

1. Garcia-Diaz, A, D. T. & Auth, J. (1995). *Principles of experimental design and analysis*. Chapman and Hall.
2. Harold. R. L. (1992). *Analysis of variance in experimental design*. USA: Springer.
3. Cochran, W. G. & Cox, G. M. (1992). *Experimental designs*. New York: John Wiley & Sons.

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