University of Dhaka
Department of Statistics
Syllabus for M.S. Courses
Session: 2021-2022

The M.S. course in statistics is spread over one academic year. The M.S. examination will be taken both in the General Group (Group A) and in the Thesis Group (Group B). Students will have to complete a total of 30 credits. There will be 22 credits of theory courses and 2 credits of general viva-voce for both Group A and Group B. Out of 22 theory credits, 15 credits are compulsory and 9 credits are to be taken from the "optional" courses. Each course will comprise of 70 percent marks for term final and 30 percent (25% marks for Incourse Examination and 5% marks for class attendance) marks for in-course assessment. The choice of optional courses will depend on the availability of teaching facilities of the department.

A selected number of students are considered for the Thesis Group on the recommendation of the Departmental Academic Committee. Each of these students shall be required to submit a thesis carrying 6 credits (4 credits for the thesis and 2 credits for its defense). The students belonging to the General Group have to take 6 credits of practical courses. For these practical courses, there will be 40% marks for the in-course assessment and the remaining 60% for the final examination.

Distribution of total credit units for the two groups:

Group A (General)	Credit	Group B (Thesis)	Credit
1. Compulsory	13	1. Compulsory	13
2. General Viva	2	2. General Viva	2
3. Optional	9	3. Optional	9
5. Practical Courses	6	5. Thesis	6
Total	**30**	**Total**	**30**

Distribution of MS Courses

Course No.	Course Title	Credit
Stat MS-501	Theory of Inference	4
Stat MS-502	Applied Multivariate Analysis	3
Stat MS-503	Design and Analysis of Experiment	3
Stat MS-504	Advanced Sampling Technique	3
Stat MS-505	General Viva	2
Total		**15**
	PRACTICAL COURSES	
Stat MS-506	Data Analysis 1: Advanced Sampling Techniques; Population Studies and Actuarial Statistics (computer-based)	2
Stat MS-507	Data Analysis 2: Applied Multivariate Analysis & Design and Analysis of Experiment	2
Stat MS-508	Data Analysis 3: Advanced Biostatistics and Advanced Econometrics	2
Total		**6**
	OPTIONAL COURSES (Any 3 Courses)	
Course No.	**Course Title**	**Credit**
Stat MS-509	Advanced Econometrics	3
Stat MS-510	Advanced Biostatistics	3
Stat MS-511	Population Studies and Actuarial Statistics	3
Stat MS-512	Theory of HANOVA	3
Stat MS-513	Advanced Operations Research	3
Stat MS-514	Robust Statistics	3
Stat MS-515	Statistical Meta-Analysis	3

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Stat MS-516	Statistical Methods for Artificial Intelligence (AI)	3
Total		**9**

Detailed Curriculum

Stat MS-501: Theory of Inference **4 Credits**

Common families of distribution: exponential families, location and scale families, inequalities and identities.

Multiple random variables: hierarchical models and mixture distributions, numerical and functional inequalities.

Properties of a random sample: order statistics, convergence concepts -- convergence in probability, almost sure convergence, convergence in distribution, the delta method.

Principles of data reduction: the sufficiency principle, sufficient statistics, minimal sufficient statistics, the likelihood principle, the likelihood function, the equivariance principle.

Point estimation: Maximum likelihood estimators, the EM algorithm, Method of evaluating estimators; mean squared error, best unbiased estimators, sufficiency and unbiasedness, loss function optimality.

Hypothesis testing: methods of finding tests -- likelihood ratio tests, union-intersection and intersection-union tests; methods of evaluating tests -- error probabilities and power function, most powerful tests, sizes of union-intersection and intersection-union tests, loss function optimality.

Interval estimation: methods of finding interval estimators -- inverting a test statistic, pivotal quantities, pivoting the CDF, methods of evaluating interval estimators -- size and coverage probability, test-related optimality, loss function optimality.

Bayesian Statistics: Difference between frequentist approach and Bayesian approach, deriving Bayes' estimator under absolute and squared error loss functions, studying different types of prior distributions, Details of Bayesian tests, Bayesian Optimality, Bayesian Intervals.

Importance of Markov Chain Monte Carlo (MCMC) methods in Statistics, algorithm of Gibbs and Metropolis-Hastings (MH) sampler for sampling from high-dimensional distribution such as posterior distribution, relationship between Gibbs and MH sampler, MCMC implementation issues.

Asymptotic evaluations: point estimation -- consistency, efficiency, bootstrap standard errors; hypothesis testing -- asymptotic distribution of LRTs, other large-sample tests; interval estimation -- approximate maximum likelihood intervals, other large-sample intervals.

Text

1. Casella, G. and Berger, R.L. (2002), *Statistical Inference*, Duxbury Advanced Series, N.Y.

References

1. Lehman, E.L., *Theory of Point Estimation.*
2. Lehman, E.L., *Test of Hypothesis.*
3. Rao, C.R. (1984), *Linear Statistical Inference and its Application*, 2nd Ed., New Delhi, Wiley Eastern.
4. Kendall, M.G. and Stuart, *The Advanced Theory of Statistics*, Vol. II.

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Stat MS-502: Applied Multivariate Analysis **3 Credits**

Principal Components: Introduction, population principal components, summarizing sample variation by principal components, large sample inferences, testing for the equal correlation structures.

Factor Analysis: Introduction, the orthogonal factor model, methods of estimation, factor rotation, factor scores.

Canonical Correlation Analysis: Introduction, canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations.

Cluster Analysis - Similarity coefficients for clustering individuals. Variables Similarity & association measures for pairs of variables methods, derivation of distance matrix, cluster variables, Agglomerative HC Algorithm for grouping N objects (items or variables). Different linkage methods with algorithm. Different types of NH Clusting method: K-means method, classification typologies & Q-sort method, Density method, Tax map method, Clamping technique or Fuzzy clustering & Partitioning methods.

Multidimensional scaling – classical, ordinal, and metrical multidimensional scaling, assessing fit and choosing the number of dimensions.

Structural equations modeling – introduction, fundamental equations for SEM, model identification, estimation techniques, assessing the fit of the model, model modification.

Data consideration and applications of Path Analysis, Correspondence Analysis, Multilevel Analysis.

Text

1. Johnson, R.A & Wichern, D.W., *Applied Multivariate Statistical Analysis*, 5th Ed., Prentice-Hall, Inc., New Jersey.

References

1. Dillon & Goldstein, *Multivariate Analysis.*
2. Manly, B.F.S. (1986), *Multivariate Statistical Methods: A Primer*, Chapman & Hall, London.
3. Lawley & Maxwell, *Factor Analysis as a Statistical Method.*
4. Everit, B.S., *Latent Variables Models.*
5. Press, S.J., *Applied Multivariate Analysis.*
6. Morrison, D.P. (1976), *Multivariate Statistical Methods*, McGraw-Hill.
7. Kshiragar, A.M., *Multivariate Analysis*, Marcel Dekker.
8. Bhuiyan, K.C. (2006), *Multivariate Analysis & its Applications,* New Central Book Agency (P) Ltd.

Stat MS-503: Design and Analysis of Experiment **3 Credits**

Preliminaries: Review of orthogonal and non-orthogonal experimental designs, their purposes and limitations, characterization of experiments: Variety trials, Factorial experiments, Bio-assays, etc.

Higher level Factorial Experiments: Concept of linear, quadratic, cubic, etc. with main and interaction effects of P^n factorial experiment, estimation of different effects and analysis procedures, Asymmetrical factorial procedures, $p \times q$ asymmetric factorial experiment.

Problems of factorial experiment. Different types of confounding, confounding with factorial experiments of level greater than 2, their estimation of effects and analysis. Methods of simultaneous confounding. Detection of factorial effects in confounding factorial experiments.

Fractional Factorial Design: Basic concepts, alias, defining contrast, etc., fractional replication of the P^n factorial design and their analysis.

Multifactor Experiments with Randomization Restrictions: Randomized Blocks and Latin Squares as multifactor designs, Split plot design, Split block design. related problems. Two-step least squares and analysis of covariance with more than one concomitant variables.

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Balanced Incomplete Block Design: Main concept, Comparison with complete designs. Relationship between parameters and their proofs, analysis of BIBD (intra-block and inter-block analysis), combined estimate, missing value estimate, use of orthogonal Latin Squares and construction of BIBD, PBIBD, Lattice design, Youden Squares, Galois field and finite projective geometry with application.

Response Surface Methodology: Main concepts, the method of Steepest Ascent, analysis of quadratic models, Response surface designs, designs of fitting first and second order model, Evolutionary operation, related problems.

Texts

1. John, P.W.M., *Statistical Design and Analysis of Experiments*, Mac-Millan.
2. Das, M.N. & Giri, N.C., *Design and Analysis of Experiment*, Wiley Eastern Limited, Delhi.

References

1. Montgomery, D., *Design and Analysis of Experiments*, Wiley.
2. Cochran and Cox, *Experimental Designs*, Wiley.
3. Yates, *Factorial Experiment.*
4. Chakrabarty, Laha and Roy, *Handbook of Statistics*, Vol. II, Wiley.
5. Seber, *Linear Regression Analysis*, Wiley.
6. Silvey, *Optimal Designs*.
7. Federer, W.T., *Experimental Designs.*
8. Bhuiyan, M.R. (2007), *Fundamentals of Experimental Design*, 2nd Ed.

Stat MS-504: Advanced Sampling Technique **3 Credits**

Review of Sample size determination: Determination of sample size for proportions under different sampling design- for equal and unequal groups (adjusting type I and type II errors). Design effect, sample size estimation in complex surveys. Sample size for longitudinal studies. Sampling designs of large scales national surveys conducted in Bangladesh- Bangladesh Demographic and Health Survey (BDHS) 2017-18, Bangladesh Urban Health Survey (UHS)2013; Bangladesh Maternal Mortality and Maternal health survey (BMMS) 2019, Multiple Indicator Cluster Survey (2019).

Sample weight and Imputation: Components of sample weights; weighted vs un-weighted estimates of population parameters.
Item non-response: Some methods for analyzing data in presence of missing valises. Methods of Imputation

Capture -Recapture sampling: Single recapture. Models for single capture -recapture; sampling design in capture-recapture. Estimating detectability with capture-recapture methods.

Adaptive sampling: Brief survey of Adaptive sampling; Adaptive cluster sampling design; estimators. Comparative efficiencies of Adaptive and conventional sampling.

Selected topics in sampling design:
Estimation of rare events- Network sampling; Dual samples.
Estimation of prevalence of disease from screening studies.
Estimation of characteristics for local areas- Synthetic estimation.
Extraction of sensitive information -randomized response technique.

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References:

1. Levy, P.S. and Lemeshow, S: Sampling of Populations
2. Thompson, S K: Sampling
3. Korn, E L and Graubard, B I: Analysis of health surveys
4. Fleiss, JL : Statistical methods for rates and proportion.

Stat MS-505: General Viva **2 Credits**

(Practical Courses)

Stat MS-506: Data Analysis 1: Advanced Sampling Techniques and Population Studies (computer-based) **2 Credits**

Advanced Sampling Techniques
Sample size determination, Weight Calculation, Capture-Recapture Sampling Method, Adaptive Sampling, Estimation of prevalence of diseases from screening studies, Synthetic estimation.

Population Studies
Application of Bongaarts model to real data, estimation of contraceptive failure and discontinuation rate, contraceptive method effectiveness, indirect estimation of fertility and mortality (infant, child and adult) rates, projection of population

Actuarial Statistics
Interest and discount; problems involving unknown length of investment and unknown rate of interest, annuity, perpetuity, capital redemption policies, net premiums, office premiums, relation between office and net premiums, construction of mortality table, techniques of calculating exposures from individual records including considerations involving selection of studies.

Stat MS-507: Data Analysis 2: Multivariate and Design **2 Credits**

(i) Inference about mean vector and variance covariance matrix of multivariate population, comparison of several multivariate means, fitting of linear and non-linear models with multivariate data, path analysis, logistic analysis, classification and grouping techniques of data by clustering, analysis of categorical data by different measures.

(ii) Analysis of P^n factorial experiments, their confoundings, fractional replicates, Analysis of non-orthogonal designs, BIBD, PBIBD, Split plot design, Split block design, Youden squares and other designs, Covariance with several variables.

Stat MS-508: Data Analysis 3: (Advanced Biostatistics and Advanced Econometrics) **2 Credits**

Advanced Econometrics
Estimation of different functional forms of regression model, Estimation of Lagged variable regression models, Estimation of panel data regression model, Estimation of Poisson regression model, Lag length selection in VAR model and lag selection criteria, Estimation of VAR model, VECM and Neural Network model.

Advanced Biostatistics
Fitting different parametric and semi-parametric regression models for failure-time data and interpretation of the parameters of the model. Analysis of lifetime data with more than one type of failures. Fitting generalized linear models and generalized linear mixed models.

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Practical Courses on other courses:

Theory of HANOVA

Problems on g-inverses and usual ANOVA in higher-way classification with interactions, variance-component analysis and use of Satterthwaite F-test, problems with mixed models, estimation of weights by different methods, applications of HANOVA techniques in different layouts.

Advanced Operations Research

Sensitivity analysis in graphical solution and simplex method, non-linear programming. Unconstrained optimization: Davidon Fletcher Powell method of minimization, Newton's method, optimal quotient method. Wolf's and Beale's method of solving QPP.

Robust Statistics

Robust confidence intervals and tests, multivariate M-estimates, MVE estimate, S-estimate, MCD estimate; Stahel-Donoho estimate, fast robust estimates for dispersion matrix, robust principal components, robust linear model building, robust estimates for the generalized linear models.

Actuarial Statistics
Interest and discount; problems involving unknown length of investment and unknown rate of interest, annuity, perpetuity, capital redemption policies, net premiums, office premiums, relation between office and net premiums, construction of mortality table, techniques of calculating exposures from individual records including considerations involving selection of studies.

Statistical Meta-analysis
Estimating effect size, testing presence of heterogeneity, graphical tests of heterogeneity, fitting fixed effects and random effects model, subgroup analysis, fitting meta-regression models, identifying publication bias, sensitivity analysis, performing meta-analysis of binary, continuous, ordinal, IPD and other types of data.

Optional Courses (Any three courses)

Stat MS-509: Advanced Econometrics **3 Credits**

Review: Econometrics, Econometric model, Aims of Econometrics, Economic data, Concept of Phillips curve. Discussion about different functional forms of Regression Models. Mixed Estimation Methods: The method of pooling cross-section and time series data.

Instrumental variables Estimation: Instrumental variable, IV method, How to choose IV in a regression model, IV estimation in a simple linear regression model and multiple regression model, 2SLS.

Lagged Variables in Econometric models: Autoregressive and distributed lag models, the reasons for lags, estimation of distributed lag models, the Koyck approach to distributed lag models, the Almon approach to distributed lag models.

Panel data regression models: Concepts, uses and application, Comparison of panel data regression model with time series data and cross-section data, Estimation of panel data regression models: the fixed effects approach, the random effects approach.

Restricted regression and re-speciation: Basic concepts, Restricted regression, Restricted least square estimate, Tests of restriction: Wald test, LM test, LR test.

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Limited Dependent Variable Regression Models: Estimation of Logit model, probit model, tobit model. Concept of GLM and linear predictor, detailed discussion about Poisson regression model.

Models of consumer demand: Consumer demand behaviour, Engel function, An almost ideal demand system (**AIDS**): basic model, incorporation of household characteristics, estimation and problems associated with it. Discussion about HIES data.

Advanced Forecasting Models: ARIMA model (Review), VAR model and estimation of VAR model, Granger Causality test, Cointegration and VECM, Neural Network model, Intervention analysis.

Time Series Econometrics: Volatility, Discussion and Estimation of ARCH model and GARCH Model.

Econometrics and Data Science: Relationship between Econometrics and Data science. Application of Econometrics in Data Science.

Texts

1. Gujarati, D.N., *Basic Econometrics,* 4th Ed.
2. Maddala, G.S., *Limited Dependent and Qualitative Variables in Econometrics,* Cambridge University Press.
3. Koutsoyiannis, A. *Theory of Econometrics*, Macmillan Press Ltd.
4. Wooldridge, J. M., *Econometrics*, Michigan State University.

References

1. Johnston, J., *Econometric Methods,* 3rd Ed.
2. Maddala, G.S., *Econometrics.*
3. Chow, G., *Econometrics.*
4. Harvey, A., The Econometric Analysis of Time Series, 2nd Ed. The London School of Economics.

Stat MS-510: Advanced Biostatistics **3 Credits**

Review of lifetime distributions, observation schemes, censoring, and likelihood, nonparametric and graphical procedures, inference procedures for parametric models and log-location-scale distributions;

Parametric regression models: Inference procedures for log-location-scale regression models (Accelerated Failure Time Models).

Semi-parametric and multiplicative hazards regression models: Methods for continuous multiplicative hazards regression models, methods for grouped lifetimes.

Multiple modes of failure: Basic characteristics and model specification, likelihood formulations, nonparametric methods, parametric methods

Goodness of fit tests: General methods for testing fits, tests of fit for specific distributions, tests of fit with regression models.

Longitudinal Models: marginal models, random effects models, transition models.

Marginal models: Binary responses, log-linear models, log-linear models for marginal means, generalized estimating equations; Count response, parametric modeling for count data, generalized estimating equation approach; Sample size calculations;

Random effect models: Estimation for generalized linear mixed models, conditional likelihood, maximum likelihood estimation; Logistic regression for binary responses, conditional likelihood approach, random effect models for binary responses; Count response: conditional likelihood method, random effect models for counts, Poisson-Gaussian random effects models.

Transition models: Fitting transition models; Transition models for categorical data; Log linear transition models for count data.

Likelihood based methods for categorical data: Generalized linear mixed models, marginalized log-linear, latent variable and transition models.

Texts

1. Lawless, J.F. (2003), *Statistical Models and Methods for Lifetime Data*, 2nd Ed., Wiley, New York.
2. Diggle, P., Heagerty, P., Liang, K.Y. and Zeger, S. (2002), *Analysis of Longitudinal Data*. Oxford University Press, New York.
3. Kalbfleisch, J.D. and Prentice, R.L. (2002), *The Statistical Analysis of Failure Time Data*, 2nd Ed., Wiley, New York.
4. Hosmer, D.W. and Lemeshow, S. (2000), *Applied Logistic Regression*, 2nd Ed., Wiley, New York.
5. Klein, J.P. and Moeschberger, M.L. (1997), *Survival Analysis,* 2nd Ed., Springer, New York.

References

1. Agresti, A., *Categorical Data Analysis,* 2nd Ed., Wiley, New York
2. McCullagh and Nelder, J.A., *Generalized Linear Models*, 2nd Ed., Chapman & Hall, New York.
3. Lee, E.T. & Wang, J.W., *Statistical Methods for Survival Data Analysis*, 3rd Ed., Wiley, New York.
4. Kleinbaum D.G. & Klein, M., *Survival Analysis: A Self-learning Text*, 2nd Ed., Springer, New York.

Stat MS-511: Population Studies and Actuarial Statistics **3 Credits**

Fertility and Its Proximate Determinants: Fertility transition theory; Concept of intermediate and proximate determinants of fertility; Davis-Blake framework; Natural fertility and its proximate determinants, Regulated fertility and its proximate determinants, Bongaarts aggregate fertility model and its applications.

Family Planning: Definition of family planning and family planning program (FPP), objectives of FPP, benefits of Family Planning, Efficacy of FPP; Contraceptive use dynamics and their measures, unmet need for contraception, FFP in Bangladesh.

Reproductive Health: Concept of reproductive health, historical development of the concept, three rights identified in reproductive health, magnitude of reproductive health problem, components of reproductive health, reproductive health indicators, the safe motherhood initiative, essential services for safe motherhood, maternal mortality, the three delays in context of maternal mortality.

Demographic Projections: Population estimates and projections, importance, limitations and assumptions of population projection, methods of population projections; Total method of population projection- arithmetic growth, geometric growth, exponential growth, logistic growth, polynomial growth. Cohort component population projection method, Isserman approach of cohort component population projection method. Projections of Households and labour force etc.

Indirect Techniques for Demographic Estimation: Estimation of fertility based on children ever born data, estimation of fertility by reverse survival methods; estimation of child mortality from information on children ever born and children surviving, estimation of adult mortality from information on orphanhood, widowhood, and distribution of deaths by age, gompartz model.

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Actuarial Statistics:

Individual short-term risk models: models for individual claims, approximations for the distributions of sum of claims, applications to insurance.

Life insurance: insurances payable at the moment of death – level benefit insurance, endowment insurance, deferred insurance, varying benefit insurance, insurances payable at the end of the year of death.

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Life annuities: single payment contingent on survival, continuous and discrete life annuities, annuities with *m*thly payments, varying annuities.

Net premiums: continuous premiums, discrete premiums, *m*thly payment premiums, apportionable premiums, accumulation type benefits.

References

1. Shryock, H.S., Siegel, J.S. et al., *The Methods and Materials of Demography*.
2. Bongaarts and Potter, *Fertility, Biology and Behaviour*, Academic Press.
3. M. Nurul Islam, Mullick and Brothers, -An Introduction to Demographic Techniques
4. G.M.R. Kpedekpo, Essentials of Demographic Analysis for Africa.
5. Keyfitz, N. and Caswell, H.: *Applied Mathematical Demography* (Third Edition)
6. Weeks, J.R., *Population.*
7. Smith, S.K., Tayman, J. and Swanson, D.A., *State and Local Population Projection - Methodology and Analysis*.
8. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbit, C.J. (1997), *Actuarial Mathematics*, 2nd Ed.
9. Kellison, S.G. (1991), *The Theory of Interests*, 2nd Ed.
10. Bathen, R.W. (1978). *Mortality Table Construction*

Stat MS-512: Theory of HANOVA **3 Credits**

Preliminaries: review of usual ANOVA and related linear algebra (g-inverses), general theorem of ANOVA and its application in usual ANOVA techniques etc.

Error decomposition techniques: problems of usual ANOVA techniques, identifiably constraints and constrains in estimators, necessity of error decomposition techniques, its application in different ANOVA techniques.

Variance–Component analysis: problems of analysis of variance component models with interaction ANOVA F-test and Satterthwaite F-test and their uses in variance –component analysis.

Weighted Analysis of Variance (WANOVA):usual assumptions of ANOVA, effects of violation of such assumptions, weighted analysis of variance (WANOVA), definition, uses and importance, WANOVA theorem of Sen and its application in different basic experimental designs, uses of error-decomposition technique in WANOVA.

Weight estimation methods: comments on WANOVA, practical problems of using such WANOVA, weights and estimation of such weights, methods of estimations of weights:

(i) MINQUE of Rao (1970)
(ii) AUE of Horn et al. (1975)
(iii) IUE of Sen (1984)

Their descriptions, applications and comparative studies.

HANOVA methods: definition, examples and uses, different approaches towards HANOVA:

(i) Adjusted approach Meier and Talukder
(ii) ASD approach of James and Sen
(iii) ADF approach of Welch
(iv) Exact approach Bishop and Dudewiez
(v) Approach of Brown and Forsylthe based on Satterthwaite approximate F-test, their comparative studies with limitations, application of such approaches.

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References

1. Scheffe, H., *Analysis of Variances*, Wiley
2. Montgomery, D.C. *Design & Analysis of Experiments.*
3. Seber, *Regression Analysis.*
4. Searle, *Linear Models.*
5. Rao & Mitra, *Generalised Inverses and its Applications.*
6. Sen, K., *Some contributions to HANOVA*, (Ph.D. Thesis)
7. Talukder, M.A.H., *Analysis of Variance with Unequal Error Variance,* (Ph.D. Thesis)

Stat MS-513: Advanced Operations Research **3 Credits**

Review: Basic concepts of operations research, sensitivity analysis in linear programming problems.

Non-linear Programming: NLPP and its applications, definition of global minimum & local minimum, difficulties introduced for nonlinearity, direction vector gradient function, convex and conver functions and relevant theorems, kuhn-tucker necessary & sufficient condition for maximization.

Unconstrained Optimization: necessary condition for the optimality of an unconstrained function, davidon fletcher powell method of minimization, newton's method, optimal quotient method.

Quadratic programming: Wolf's and Beale's method of solving QPP and related theorem, Separable programming: linearization of a non-linear function and its seperation by separable programming technique.

References

1. Vajda, S., *The Theory of Games and Linear Programming.*
2. Hadley,G., *Linear Programming,* Addison Wisley.
3. Goss, *Linear Programming,* McGraw-Hill.
4. Garvin, W.W. (1910), *Introduction to Linear Programming*, McGraw-Hill Book Co., N.Y.
5. Bazaraa, M.S. and Shetty, C.M.G., *Non-linear Programming: Theory and Algorithms,* Wiley, N.Y.
6. OHinenelblaw, P.M., *Applied Non-linear Programming*, McGraw-Hill, N.Y.
7. Englewoodcliffes,N.J. (1969), *Non-linear Programming - a Unified Approach*, Prentice Hall.
8. Arrow, K.J. L. Hurwicz and Uzawa, H. (editors) (1958), *Studies in Linear Programming,* Stanford University Press.

Stat MS-514: Robust Statistics **3 Credits**

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Introduction: review of Stat H-408 (Introduction to Robust Statistics).

Robust confidence intervals and tests

Optimal robustness: bias and variance optimality of location estimates, bias optimality of scale and dispersion estimates, the infinitesimal approach, the Hampel approach.

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Estimates viewed as functionals

Multivariate analysis: breakdown and efficiency of multivariate estimates, multivariate M-estimates, estimates based on a robust scale - MVE estimate, S-estimate, MCD estimate; Stahel-Denoho estimate, fast robust estimates for dispersion matrix.

Robust principal components: robust PCA based on a robust scale, spherical principal components.

Robust linear model building: robust AIC, C_p and FPE criteria, robust step-by-step algorithms.

Robust estimates for the generalized linear models.

Text

1. Maronna, R.A., Martin R. D., and Yohai, V. J. (2006), *Robust Statistics: Theory and Methods*, John Wiley & Sons.

References

1. Hampel, F.R., Ronchetti, E.M., Rousseeuw, P.J., and Stahel, W.A. (1986), *Robust Statistics: The Approach Based on Influence Functions*, John Wiley & Sons.
2. Huber, P.J. (1981), *Robust Statistics*, John Wiley & Sons.

Stat MS-515: Statistical Meta-analysis **3 Credits**

Introduction to Meta-analysis: its development and uses, evidence-based health care, systematic reviews, why meta-analysis? Outcomes variables and effect size, binary, continuous, ordinal outcome measures.

Issues of meta-analysis: assessing between study heterogeneity, test of heterogeneity, possible causes of heterogeneity, methods for investigating and dealing with heterogeneity, validity of pooling studies with heterogeneity. Quasi-empirical Bayes method.

Fixed effects methods for combining studies: inverse variance weighted method, specific methods for combining odds ratios: Mantel-Haenszel method, Peto's method, exact methods for interval estimation.

Random effects model: algebraic derivation, restricted maximum likelihood estimates, comparison of estimation methods, extensions to the random effects model. Subgroup analysis, meta-regression models, mixed effects models, extension of mixed modeling.

Publication bias: evidence and consequences of publication bias, identifying publication bias, funnel plot, adjusting the publication bias.

Study quality: methodological factors affecting the study quality, incorporating study quality in meta-analysis, Quality effects model. Sensitivity analysis, sensitivity of results to meta-analytic methods.

Reporting the results of a meta-analysis: overview and structure of a report, graphical displays used for reporting, data collection and quality, PRISM.

Bayesian methods in meta-analysis: Bayesian methods in health research, Bayesian meta-analysis of normally distributed data, Bayesian meta-analysis of binary data. Empirical Bayes methods in meta-analysis. Missing data, Bayesian methods of missing data.

Meta-analysis of different types of data: Meta-analysis of individual patient data (IPD). Vote counting methods, combining p-values. Meta-analysis of multiple and correlated outcome measures. Meta-analysis of epidemiological and other observational studies. Meta-analysis of survival data.

Softwares: rmeta, meta, etc packages in R, comprehensive meta-analysis.

23/3/23

(সায়েমা শারমিন)
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Text

1. Sutton, A. J., Abrams, K. R., Jones, D. R., Sheldon, T. A., Song, F. (2000), *Methods for Meta-Analysis in Medical Research*, John Wiley & Sons Ltd, West Sussex PO19 1UD, England.

References

1. Borenstein, M., Hedges, L. V. (2009), *Introduction to meta-analysis*, John Wiley & Sons, Ltd.
2. Shahjahan Khan: *Meta-Analysis: Methods for Health and Experimental Studies.* Springer Singapore, 2020 2020 9811550328, 97898115503 24
3. Hedges, L. V., and Olkin, I. (1985), *Statistical Methods for Meta-Analysis,* John Wiley & Sons, Inc.
4. Hartung, J., Knapp, G., Sinha, B. S. (2008), *Statistical Meta-Analysis with Applications,* John Wiley & Sons, Inc.

5. Kulinskaya, E., Morgenthaler, S., Staudte, R. G. (2008), *Meta Analysis: A Guide to Calibrating and Combining Statistical Evidence*, John Wiley & Sons, Ltd.
6. Cochrane Handbook for Systematic Reviews of Interventions, *http://www.cochrane.org/training/cochrane-handbook*.

Stat MS-516: Statistical Methods for Artificial Intelligence **3 Credits**

Introduction – What is Artificial intelligence (AI), Application of AI, Philosophy of AI, AI research: problem of AI, approaches to AI.

Intelligent Agents – Agents and environments, Good behavior of the agents, Performance measures, The nature of environments, structure of agents: Simple reflex agents, Model based reflex agents, Goal based agents, Utility based agents.

Problem solving – problem solving agents, formulating problem, uniformed search strategies: Breadth-first search, Depth-first search, Depth limited search, Iterative deepening depth- first search, Bidirectional search, Comparing uninformed search strategies.

Informed search strategies – heuristic function, Greedy best-first Search, local search algorithms and optimistic problems: simulated annealing search and genetic algorithms.

Knowledge representation – Knowledge based agents, prepositional logic, Syntax and semantics, Equivalence, Validity and Satisfiability, Resolution, Conjunctive normal form (CNF).

First order logic – representation revisited, Syntax and semantics for first order logic, Using first order logic, Inference in First order logic, prepositional versus first order logic, Knowledge engineering in first order logic.

Uncertain knowledge and reasoning – Handling uncertain knowledge (using knowledge of probability), inference using full joint distribution, independence, Bayes' rules and its use (simple case and combining evidence).
Probabilistic reasoning – Bayesian network, method for constructing Bayesian networks, conditional independence relations in Bayesian networks, Bayesian nets with continuous variables, exact inference in Bayesian network: variable elimination algorithm, approximate inference in Bayesian network: direct sampling methods, rejection sampling in Bayesian networks, Fuzzy sets and fuzzy logic in the context of uncertain reasoning.

Statistical Learning Methods – Learning with complete data: Maximum-likelihood parameter learning (both discrete and continuous models), Naïve Bayes' models, Decision Tree learning. Learning with hidden variables: EM algorithm. Instance based learning: Nearest Neighbor models, Kernel models. Neural Networks: Neural Networks, Units in neural networks, Network structures (single and Multilayer feed forward).

Text
Russell, S. and Norvig, P. (2004), *Artificial Intelligence: A Modern Approach*, 2nd Edition, Pearson Education / Prentice Hall of India.

References
1. Nilsson, N.J. (2000), *Artificial Intelligence: A new Synthesis*, Harcourt Asia Pvt. Ltd.
2. Rich, E. and Knight, K. (2003), *Artificial Intelligence*, 2nd Edition, Tata McGraw-Hill.

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The End