STATISTICAL ANALYSIS WITH MISSING DATA

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Abstract

Research of advanced techniques for processing multidimensional missing data is presented. The theoretical part of study is focused on the review of the different data imputation methods to handle missing data. The practical part of study is presented machine learning algorithms such as random forest, logistic regression, and nearest neighbor method to solve classification problem for data with artificial and natural missing values.

Keywords: missing value, imputation method, machine learning algorithm, accuracy

Problem formulation. Data matrix $X^{(n \times d)}$ is specified. Some of the values are not observed. It is necessary to restore data matrix for the application of machine learning algorithms to solve classification problems.

Removing objects with missing values. One of the simplest ways to solve problem of processing missing values is to remove the objects (rows of data matrix) that have missing values. This method is used when a small number of objects is not observed. The loss of information is the only drawback of this method. Removing features that have a small number of missing values is an alternative method.

Imputation with a special value. The second easiest method is to impute the missing data with a special predefined value (for example, zero or minus one). This approach does not reduce the sample size, but it can add to data matrix values that are significantly different from the real ones. It is appropriate to impute missing values with a value that does not occur in the data matrix (for example, minus one for non-negative values) for further application of machine learning algorithms based on decision trees and impute missing values with zero for algorithms that are sensitive to the features scale.

Mode imputation. The third easiest method is to impute the missing values of categorical feature by mode of the non-missing values of that feature.

Mean imputation. The fourth simplest method is to impute the missing values of numerical feature by mean of the non-missing values of that feature.

SVD imputation. Let's consider the method of replacing missing values using the singular value decomposition of data matrix. First, missing values are replaced by mean of the non-missing values for each feature in data matrix, then, these mean values are replaced by the nearest unique values for each feature to preserve the nature of data.

Second, the decomposition of data matrix is found in the form

$$X^{(n \times d)} = U^{(n \times n)} S^{(n \times d)} V^{(d \times d)},$$

where $S^{(n \times d)}$ is a singular matrix (it is diagonal matrix with the roots of the eigenvalues of the matrix $X^{(n \times d)} \left(X^{(n \times d)} \right)^T$ in descending order on the main diagonal). The matrices $U^{(n \times n)}$, $V^{(d \times d)}$ are orthogonal and, in addition, the columns of the matrix $U^{(n \times n)}$ are the eigenvectors of the matrix $X^{(n \times d)}$, and the matrix $V^{(d \times d)}$ can be presented in the form $V^{(d \times d)} = \left(S^{(n \times d)} \right)^{-1} \left(U^{(n \times n)} \right)^T X^{(n \times d)}$.

Third, the first r rows and columns are selected in matrix $S^{(n \times d)}$, and all remaining ones are deleted. The first r most significant singular values are called principal components.

Statistical Analysis With Missing Data

Adam Davey,Jyoti "Tina" Savla

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and silent attendees of all the events and with a modicum of reluctance the grey gures who kept inquiring whether I was any nearer the completion of whatever stage I had been foolish enough to attach a date *Missing Data* John W. Graham,2012-06-08 Missing data have long plagued those conducting applied research in the social behavioral and health sciences Good missing data analysis solutions are available but practical information about implementation of these solutions has been lacking The objective of Missing Data Analysis and Design is to enable investigators who are non statisticians to implement modern missing data procedures properly in their research and reap the benefits in terms of improved accuracy and statistical power Missing Data Analysis and Design contains essential information for both beginners and advanced readers For researchers with limited missing data analysis experience this book offers an easy to read introduction to the theoretical underpinnings of analysis of missing data provides clear step by step instructions for performing state of the art multiple imputation analyses and offers practical advice based on over 20 years experience for avoiding and troubleshooting problems For more advanced readers unique discussions of attrition non Monte Carlo techniques for simulations involving missing data evaluation of the benefits of auxiliary variables and highly cost effective planned missing data designs are provided The author lays out missing data theory in a plain English style that is accessible and precise Most analysis described in the book are conducted using the well known statistical software packages SAS and SPSS supplemented by Norm 2 03 and associated Java based automation utilities A related web site contains free downloads of the supplementary software as well as sample empirical data sets and a variety of practical exercises described in the book to enhance and reinforce the reader s learning experience Missing Data Analysis and Design and its web site work together to enable beginners to gain confidence in their ability to conduct missing data analysis and more advancedreaders to expand their skill set *Missing Data* Patrick E. McKnight,Katherine M. McKnight,Souraya Sidani,Aurelio José Figueredo,2007-03-28 While most books on missing data focus on applying sophisticated statistical techniques to deal with the problem after it has occurred this volume provides a methodology for the control and prevention of missing data In clear nontechnical language the authors help the reader understand the different types of missing data and their implications for the reliability validity and generalizability of a study s conclusions They provide practical recommendations for designing studies that decrease the likelihood of missing data and for addressing this important issue when reporting study results When statistical remedies are needed such as deletion procedures augmentation methods and single imputation and multiple imputation procedures the book also explains how to make sound decisions about their use Patrick E McKnight s website offers a periodically updated annotated bibliography on missing data and links to other Web resources that address missing data *Multiple Imputation of Missing Data in Practice* Yulei He,Guangyu Zhang,Chiu-Hsieh Hsu,2021-11-19 Multiple Imputation of Missing Data in Practice Basic Theory and Analysis Strategies provides a comprehensive introduction to the multiple imputation approach to missing data problems that are often encountered in data analysis Over the past 40 years or so multiple imputation has gone

through rapid development in both theories and applications It is nowadays the most versatile popular and effective missing data strategy that is used by researchers and practitioners across different fields There is a strong need to better understand and learn about multiple imputation in the research and practical community Accessible to a broad audience this book explains statistical concepts of missing data problems and the associated terminology It focuses on how to address missing data problems using multiple imputation It describes the basic theory behind multiple imputation and many commonly used models and methods These ideas are illustrated by examples from a wide variety of missing data problems Real data from studies with different designs and features e g cross sectional data longitudinal data complex surveys survival data studies subject to measurement error etc are used to demonstrate the methods In order for readers not only to know how to use the methods but understand why multiple imputation works and how to choose appropriate methods simulation studies are used to assess the performance of the multiple imputation methods Example datasets and sample programming code are either included in the book or available at a github site https github com he zhang hsu multiple_imputation_book Key Features Provides an overview of statistical concepts that are useful for better understanding missing data problems and multiple imputation analysis Provides a detailed discussion on multiple imputation models and methods targeted to different types of missing data problems e g univariate and multivariate missing data problems missing data in survival analysis longitudinal data complex surveys etc Explores measurement error problems with multiple imputation Discusses analysis strategies for multiple imputation diagnostics Discusses data production issues when the goal of multiple imputation is to release datasets for public use as done by organizations that process and manage large scale surveys with nonresponse problems For some examples illustrative datasets and sample programming code from popular statistical packages e g SAS R WinBUGS are included in the book For others they are available at a github site https github com he zhang hsu multiple_imputation_book

Applied Missing Data Analysis Craig K. Enders,2010-04-23 Walking readers step by step through complex concepts this book translates missing data techniques into something that applied researchers and graduate students can understand and utilize in their own research Enders explains the rationale and procedural details for maximum likelihood estimation Bayesian estimation multiple imputation and models for handling missing not at random MNAR data Easy to follow examples and small simulated data sets illustrate the techniques and clarify the underlying principles The companion website includes data files and syntax for the examples in the book as well as up to date information on software The book is accessible to substantive researchers while providing a level of detail that will satisfy quantitative specialists This book will appeal to researchers and graduate students in psychology education management family studies public health sociology and political science It will also serve as a supplemental text for doctoral level courses or seminars in advanced quantitative methods survey analysis longitudinal data analysis and multilevel modeling and as a primary text for doctoral level courses or seminars in missing data **Statistical Analysis of Proteomic Data** Thomas Burger,2022-10-29 This book explores the

most important processing steps of proteomics data analysis and presents practical guidelines as well as software tools that are both user friendly and state of the art in chemo and biostatistics Beginning with methods to control the false discovery rate FDR the volume continues with chapters devoted to software suites for constructing quantitation data tables missing value related issues differential analysis software and more Written for the highly successful Methods in Molecular Biology series chapters include the kind of detail and implementation advice that leads to successful results Authoritative and practical Statistical Analysis of Proteomic Data Methods and Tools serves as an ideal guide for proteomics researchers looking to extract the best of their data with state of the art tools while also deepening their understanding of data analysis

Statistical Analysis With Missing Data R.J.A. Little, *NURSING RESEARCH AND STATISTICS (M.Sc Nursing 1st year)* Dr. Tulshi Shringi, Dr. Roshani Gautam, Dr. Sonia V. Beri,2025-09-30 It s with great happiness that I would like to acknowledge a great deal of people that get helped me extremely through the entire difficult challenging but a rewarding and interesting path towards some sort of Edited Book without having their help and support none of this work could have been possible **Quasi-Experimentation** Charles S. Reichardt,2019-08-15 Featuring engaging examples from diverse disciplines this book explains how to use modern approaches to quasi experimentation to derive credible estimates of treatment effects under the demanding constraints of field settings Foremost expert Charles S Reichardt provides an in depth examination of the design and statistical analysis of pretest posttest nonequivalent groups regression discontinuity and interrupted time series designs He details their relative strengths and weaknesses and offers practical advice about their use Reichardt compares quasi experiments to randomized experiments and discusses when and why the former might be a better choice Modern moethods for elaborating a research design to remove bias from estimates of treatment effects are described as are tactics for dealing with missing data and noncompliance with treatment assignment Throughout mathematical equations are translated into words to enhance accessibility *Statistical Methods for Handling Incomplete Data* Jae Kwang Kim,Jun Shao,2013-07-23 Along with many examples this text covers the most up to date statistical theories and computational methods for analyzing incomplete data It presents a thorough treatment of statistical theories of likelihood based inference with missing data It also discusses numerous computational techniques and theories on imputation and extensively covers methods involving propensity score weighting nonignorable missing data longitudinal missing data survey sampling and statistical matching Some of the research ideas introduced can be developed further for specific applications

Population Ecology in Practice Dennis L. Murray,Brett K. Sandercock,2020-02-10 A synthesis of contemporary analytical and modeling approaches in population ecology The book provides an overview of the key analytical approaches that are currently used in demographic genetic and spatial analyses in population ecology The chapters present current problems introduce advances in analytical methods and models and demonstrate the applications of quantitative methods to ecological data The book covers new tools for designing robust field studies estimation of abundance and demographic rates

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