A Bayesian Semiparametric Regression Model for Joint Analysis of Microbiome Data

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The successional dynamics of microbial communities are influenced by the synergistic interactions of physical and biological factors. In our motivating data, ocean microbiome samples were collected from the Santa Cruz Municipal Wharf, Monterey Bay at multiple time points and then 16S ribosomal RNA (rRNA) sequenced. We develop a Bayesian semiparametric regression model to investigate how microbial abundance and succession change with covarying physical and biological factors including algal bloom and domoic acid concentration level using 16S rRNA sequencing data. A generalized linear regression model is built using the Laplace prior, a sparse inducing prior, to improve estimation of covariate effects on mean abundances of microbial species represented by operational taxonomic units (OTUs). A nonparametric prior model is used to facilitate borrowing strength across OTUs, across samples and across time points. It flexibly estimates baseline mean abundances of OTUs and provides the basis for improved quantification of covariate effects. The proposed method does not require prior normalization of OTU counts to adjust differences in sample total counts. Instead, the normalization and estimation of covariate effects on OTU abundance are simultaneously carried out for joint analysis of all OTUs. Using simulation studies and a real data analysis, we demonstrate improved inference compared to an existing method.

Keywords: count data, Laplace prior, metagenomics, microbiome, regularizing prior, process convolution, negative binomial model, 16S ribosomal RNA sequencing

1. INTRODUCTION

Microbial communities are influenced by several factors whether they live in the host's guts or other occupied niches. Their successional dynamics could further change in response to perturbations of the host or of the surrounding environments (Turnbaugh et al., 2009; Needham and Fuhrman, 2016). Understanding how abiotic and biotic factors influence the dynamics of microbial communities is of great interest in the field of microbiome studies. Recent revolutionary advances in next-generation sequencing (NGS) technologies along with rapidly decreasing costs, have facilitated the accumulation of large datasets of 16S ribosomal RNA (rRNA) amplicon sequences across various disciplines such as medicine, biology, ecology, and environmental sciences (Woo et al., 2008). Sequencing data is usually pre-treated for quality filtering, noise removal and chimera checking through bioinformatics algorithms and the filtered sequences are clustered into Operational Taxonomic Units (OTUs), which represent similar organisms (microbial species) based on sequence homology (called OTU picking). An OTU abundance table is generated,

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Nils Lid Hjort,Chris Holmes,Peter Müller,Stephen G. Walker

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Joint Modeling of Longitudinal and Time-to-Event Data Robert Elashoff,Gang li,Ning Li,2016-10-04 Longitudinal studies often incur several problems that challenge standard statistical methods for data analysis These problems include non ignorable missing data in longitudinal measurements of one or more response variables informative observation times of longitudinal data and survival analysis with intermittently measured time dependent covariates that are subject to measurement error and or substantial biological variation Joint modeling of longitudinal and time to event data has emerged as a novel approach to handle these issues Joint Modeling of Longitudinal and Time to Event Data provides a systematic introduction and review of state of the art statistical methodology in this active research field The methods are illustrated by real data examples from a wide range of clinical research topics A collection of data sets and software for practical implementation of the joint modeling methodologies are available through the book website This book serves as a reference book for scientific investigators who need to analyze longitudinal and or survival data as well as researchers developing methodology in this field It may also be used as a textbook for a graduate level course in biostatistics or statistics **Joint Models for Longitudinal and Time-to-Event Data** Dimitris Rizopoulos,2012-06-22 In longitudinal studies it is often of interest to investigate how a marker that is repeatedly measured in time is associated with a time to an event of interest e g prostate cancer studies where longitudinal PSA level measurements are collected in conjunction with the time to recurrence Joint Models for Longitudinal and Time to Event Data With Applications in R provides a full treatment of random effects joint models for longitudinal and time to event outcomes that can be utilized to analyze such data The content is primarily explanatory focusing on applications of joint modeling but sufficient mathematical details are provided to facilitate understanding of the key features of these models All illustrations put forward can be implemented in the R programming language via the freely available package JM written by the author All the R code used in the book is available at http jmr r forge r project org Nonparametric Bayesian Inference in Biostatistics Riten Mitra,Peter Müller,2015-07-25 As chapters in this book demonstrate BNP has important uses in clinical sciences and inference for issues like unknown partitions in genomics Nonparametric Bayesian approaches BNP play an ever expanding role in biostatistical inference from use in proteomics to clinical trials Many research problems involve an abundance of data and require flexible and complex probability models beyond the traditional parametric approaches As this book s expert contributors show BNP approaches can be the answer Survival Analysis in particular survival regression has traditionally used BNP but BNP s potential is now very broad This applies to important tasks like arrangement of patients into clinically meaningful subpopulations and segmenting the genome into functionally distinct regions This book is designed to both review and introduce application areas for BNP While existing books provide theoretical foundations this book connects theory to practice through engaging examples and research questions Chapters cover clinical trials spatial inference proteomics genomics clustering survival

analysis and ROC curve *Bayesian Hierarchical Models* Peter D. Congdon,2019-09-16 An intermediate level treatment of Bayesian hierarchical models and their applications this book demonstrates the advantages of a Bayesian approach to data sets involving inferences for collections of related units or variables and in methods where parameters can be treated as random collections Through illustrative data analysis and attention to statistical computing this book facilitates practical implementation of Bayesian hierarchical methods The new edition is a revision of the book Applied Bayesian Hierarchical Methods It maintains a focus on applied modelling and data analysis but now using entirely R based Bayesian computing options It has been updated with a new chapter on regression for causal effects and one on computing options and strategies This latter chapter is particularly important due to recent advances in Bayesian computing and estimation including the development of rjags and rstan It also features updates throughout with new examples The examples exploit and illustrate the broader advantages of the R computing environment while allowing readers to explore alternative likelihood assumptions regression structures and assumptions on prior densities Features Provides a comprehensive and accessible overview of applied Bayesian hierarchical modelling Includes many real data examples to illustrate different modelling topics R code based on rjags jagsUI R2OpenBUGS and rstan is integrated into the book emphasizing implementation Software options and coding principles are introduced in new chapter on computing Programs and data sets available on the book s website *Bayesian Statistics in Action* Raffaele Argiento,Ettore Lanzarone,Isadora Antoniano Villalobos,Alessandra Mattei,2017-04-28 This book is a selection of peer reviewed contributions presented at the third Bayesian Young Statisticians Meeting BAYSM 2016 Florence Italy June 19 21 The meeting provided a unique opportunity for young researchers M S students Ph D students and postdocs dealing with Bayesian statistics to connect with the Bayesian community at large to exchange ideas and to network with others working in the same field The contributions develop and apply Bayesian methods in a variety of fields ranging from the traditional e g biostatistics and reliability to the most innovative ones e g big data and networks **Bayesian Nonparametrics** Nils Lid Hjort,Chris Holmes,Peter Müller,Stephen G. Walker,2010-04-12 Bayesian nonparametrics works theoretically computationally The theory provides highly flexible models whose complexity grows appropriately with the amount of data Computational issues though challenging are no longer intractable All that is needed is an entry point this intelligent book is the perfect guide to what can seem a forbidding landscape Tutorial chapters by Ghosal Lijoi and Pr nster Teh and Jordan and Dunson advance from theory to basic models and hierarchical modeling to applications and implementation particularly in computer science and biostatistics These are complemented by companion chapters by the editors and Griffin and Quintana providing additional models examining computational issues identifying future growth areas and giving links to related topics This coherent text gives ready access both to underlying principles and to state of the art practice Specific examples are drawn from information retrieval NLP machine vision computational biology biostatistics and bioinformatics **Bayesian Thinking, Modeling and Computation** ,2005-11-29 This volume describes how to

develop Bayesian thinking modelling and computation both from philosophical methodological and application point of view It further describes parametric and nonparametric Bayesian methods for modelling and how to use modern computational methods to summarize inferences using simulation The book covers wide range of topics including objective and subjective Bayesian inferences with a variety of applications in modelling categorical survival spatial spatiotemporal Epidemiological software reliability small area and micro array data The book concludes with a chapter on how to teach Bayesian thoughts to nonstatisticians Critical thinking on causal effects Objective Bayesian philosophy Nonparametric Bayesian methodology Simulation based computing techniques Bioinformatics and Biostatistics **Applied Statistics in Biomedicine and Clinical Trials Design** Zhen Chen,Aiyi Liu,Yongming Qu,Larry Tang,Naitee Ting,Yi Tsong,2015-05-04 This volume is a unique combination of papers that cover critical topics in biostatistics from academic government and industry perspectives The 6 sections cover Bayesian methods in biomedical research Diagnostic medicine and classification Innovative Clinical Trials Design Modelling and Data Analysis Personalized Medicine and Statistical Genomics The real world applications are in clinical trials diagnostic medicine and genetics The peer reviewed contributions were solicited and selected from some 400 presentations at the annual meeting of the International Chinese Statistical Association ICSA held with the International Society for Biopharmaceutical Statistics ISBS The conference was held in Bethesda in June 2013 and the material has been subsequently edited and expanded to cover the most recent developments **The Mathematics of the Uncertain** Eduardo Gil,Eva Gil,Juan Gil,María Ángeles Gil,2018-02-28 This book is a tribute to Professor Pedro Gil who created the Department of Statistics OR and TM at the University of Oviedo and a former President of the Spanish Society of Statistics and OR SEIO In more than eighty original contributions it illustrates the extent to which Mathematics can help manage uncertainty a factor that is inherent to real life Today it goes without saying that in order to model experiments and systems and to analyze related outcomes and data it is necessary to consider formal ideas and develop scientific approaches and techniques for dealing with uncertainty Mathematics is crucial in this endeavor as this book demonstrates As Professor Pedro Gil highlighted twenty years ago there are several well known mathematical branches for this purpose including Mathematics of chance Probability and Statistics Mathematics of communication Information Theory and Mathematics of imprecision Fuzzy Sets Theory and others These branches often intertwine since different sources of uncertainty can coexist and they are not exhaustive While most of the papers presented here address the three aforementioned fields some hail from other Mathematical disciplines such as Operations Research others in turn put the spotlight on real world studies and applications The intended audience of this book is mainly statisticians mathematicians and computer scientists but practitioners in these areas will certainly also find the book a very interesting read **Measurement Error in Nonlinear Models** Raymond J. Carroll,David Ruppert,Leonard A. Stefanski,Ciprian M. Crainiceanu,2006-06-21 It s been over a decade since the first edition of Measurement Error in Nonlinear Models splashed onto the scene and research in the field has certainly not cooled in the

interim In fact quite the opposite has occurred As a result Measurement Error in Nonlinear Models A Modern Perspective Second Edition has been revamped and ex *Handbook of Survival Analysis* John P. Klein,Hans C. van Houwelingen,Joseph G. Ibrahim,Thomas H. Scheike,2016-04-19 Handbook of Survival Analysis presents modern techniques and research problems in lifetime data analysis This area of statistics deals with time to event data that is complicated by censoring and the dynamic nature of events occurring in time With chapters written by leading researchers in the field the handbook focuses on advances in survival analysis techniques covering classical and Bayesian approaches It gives a complete overview of the current status of survival analysis and should inspire further research in the field Accessible to a wide range of readers the book provides An introduction to various areas in survival analysis for graduate students and novices A reference to modern investigations into survival analysis for more established researchers A text or supplement for a second or advanced course in survival analysis A useful guide to statistical methods for analyzing survival data experiments for practicing statisticians **Biodemography of Aging** Anatoliy I. Yashin,Eric Stallard,Kenneth C. Land,2016-08-22 This volume is a critical exposition of the data and analyses from a full decade of rigorous research into how age related changes at the individual level along with other factors contribute to morbidity disability and mortality risks at the broader population level After summarizing the state of our knowledge in the field individual chapters offer enlightening discussion on a range of key topics such as age trajectory analysis in select and general populations incidence age patterns of major chronic illnesses and indices of cumulative deficits and their use in characterizing and understanding the detailed properties of individual aging The book features comprehensive statistical analyses of unique longitudinal data sets including the unique resource of the Framingham Heart Study with its more than 60 years of follow up Culminating in penetrating conclusions about the insights gained from the work involved this book adds much to our understanding of the links between aging and human health *Bayesian Data Analysis, Third Edition* Andrew Gelman,John B. Carlin,Hal S. Stern,David B. Dunson,Aki Vehtari,Donald B. Rubin,2013-11-01 Now in its third edition this classic book is widely considered the leading text on Bayesian methods lauded for its accessible practical approach to analyzing data and solving research problems Bayesian Data Analysis Third Edition continues to take an applied approach to analysis using up to date Bayesian methods The authors all leaders in the statistics community introduce basic concepts from a data analytic perspective before presenting advanced methods Throughout the text numerous worked examples drawn from real applications and research emphasize the use of Bayesian inference in practice New to the Third Edition Four new chapters on nonparametric modeling Coverage of weakly informative priors and boundary avoiding priors Updated discussion of cross validation and predictive information criteria Improved convergence monitoring and effective sample size calculations for iterative simulation Presentations of Hamiltonian Monte Carlo variational Bayes and expectation propagation New and revised software code The book can be used in three different ways For undergraduate students it introduces Bayesian inference starting from first principles For graduate students the text

presents effective current approaches to Bayesian modeling and computation in statistics and related fields For researchers it provides an assortment of Bayesian methods in applied statistics Additional materials including data sets used in the examples solutions to selected exercises and software instructions are available on the book s web page <u>Statistical Analysis with Measurement Error or Misclassification</u> Grace Y. Yi,2017-08-02 This monograph on measurement error and misclassification covers a broad range of problems and emphasizes unique features in modeling and analyzing problems arising from medical research and epidemiological studies Many measurement error and misclassification problems have been addressed in various fields over the years as well as with a wide spectrum of data including event history data such as survival data and recurrent event data correlated data such as longitudinal data and clustered data multi state event data and data arising from case control studies Statistical Analysis with Measurement Error or Misclassification Strategy Method and Application brings together assorted methods in a single text and provides an update of recent developments for a variety of settings Measurement error effects and strategies of handling mismeasurement for different models are closely examined in combination with applications to specific problems Readers with diverse backgrounds and objectives can utilize this text Familiarity with inference methods such as likelihood and estimating function theory or modeling schemes in varying settings such as survival analysis and longitudinal data analysis can result in a full appreciation of the material but it is not essential since each chapter provides basic inference frameworks and background information on an individual topic to ease the access of the material The text is presented in a coherent and self contained manner and highlights the essence of commonly used modeling and inference methods This text can serve as a reference book for researchers interested in statistical methodology for handling data with measurement error or misclassification as a textbook for graduate students especially for those majoring in statistics and biostatistics or as a book for applied statisticians whose interest focuses on analysis of error contaminated data Grace Y Yi is Professor of Statistics and University Research Chair at the University of Waterloo She is the 2010 winner of the CRM SSC Prize an honor awarded in recognition of a statistical scientist s professional accomplishments in research during the first 15 years after having received a doctorate She is a Fellow of the American Statistical Association and an Elected Member of the International Statistical Institute **Advanced Survival Models** Catherine Legrand,2021-03-22 Survival data analysis is a very broad field of statistics encompassing a large variety of methods used in a wide range of applications and in particular in medical research During the last twenty years several extensions of classical survival models have been developed to address particular situations often encountered in practice This book aims to gather in a single reference the most commonly used extensions such as frailty models in case of unobserved heterogeneity or clustered data cure models when a fraction of the population will not experience the event of interest competing risk models in case of different types of event and joint survival models for a time to event endpoint and a longitudinal outcome Features Presents state of the art approaches for different advanced survival models including frailty

models cure models competing risk models and joint models for a longitudinal and a survival outcome Uses consistent notation throughout the book for the different techniques presented Explains in which situation each of these models should be used and how they are linked to specific research questions Focuses on the understanding of the models their implementation and their interpretation with an appropriate level of methodological development for masters students and applied statisticians Provides references to existing R packages and SAS procedure or macros and illustrates the use of the main ones on real datasets This book is primarily aimed at applied statisticians and graduate students of statistics and biostatistics It can also serve as an introductory reference for methodological researchers interested in the main extensions of classical survival analysis *Big Data Analytics in Oncology with R* Atanu Bhattacharjee,2022-12-29 Big Data Analytics in Oncology with R serves the analytical approaches for big data analysis There is huge progressed in advanced computation with R But there are several technical challenges faced to work with big data These challenges are with computational aspect and work with fastest way to get computational results Clinical decision through genomic information and survival outcomes are now unavoidable in cutting edge oncology research This book is intended to provide a comprehensive text to work with some recent development in the area Features Covers gene expression data analysis using R and survival analysis using R Includes bayesian in survival gene expression analysis Discusses competing gene expression analysis using R Covers Bayesian on survival with omics data This book is aimed primarily at graduates and researchers studying survival analysis or statistical methods in genetics Computational Statistics and Applications Ricardo López-Ruiz,2022-04-06 Nature evolves mainly in a statistical way Different strategies formulas and conformations are continuously confronted in the natural processes Some of them are selected and then the evolution continues with a new loop of confrontation for the next generation of phenomena and living beings Failings are corrected without a previous program or design The new options generated by different statistical and random scenarios lead to solutions for surviving the present conditions This is the general panorama for all scrutiny levels of the life cycles Over three sections this book examines different statistical questions and techniques in the context of machine learning and clustering methods the frailty models used in survival analysis and other studies of statistics applied to diverse problems Dynamical Biostatistical Models Daniel Commenges,Helene Jacqmin-Gadda,2015-10-02 Dynamical Biostatistical Models presents statistical models and methods for the analysis of longitudinal data The book focuses on models for analyzing repeated measures of quantitative and qualitative variables and events history including survival and multistate models Most of the advanced methods such as multistate and joint models can be ap *Advances in Theoretical and Applied Statistics* Nicola Torelli,Fortunato Pesarin,Avner Bar-Hen,2013-06-26 This volume includes contributions selected after a double blind review process and presented as a preliminary version at the 45th Meeting of the Italian Statistical Society The papers provide significant and innovative original contributions and cover a broad range of topics including statistical theory methods for time series and spatial data

statistical modeling and data analysis survey methodology and official statistics analysis of social demographic and health data and economic statistics and econometrics **Applied Bayesian Modelling** Peter Congdon,2014-05-23 This book provides an accessible approach to Bayesian computing and data analysis with an emphasis on the interpretation of real data sets Following in the tradition of the successful first edition this book aims to make a wide range of statistical modeling applications accessible using tested code that can be readily adapted to the reader s own applications The second edition has been thoroughly reworked and updated to take account of advances in the field A new set of worked examples is included The novel aspect of the first edition was the coverage of statistical modeling using WinBUGS and OPENBUGS This feature continues in the new edition along with examples using R to broaden appeal and for completeness of coverage

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