

JUMP: replicability analysis of high-throughput experiments with applications to spatial transcriptomic studies

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Abstract

Motivation: Replicability is the cornerstone of scientific research. The current statistical method for high-dimensional replicability analysis either cannot control the false discovery rate (FDR) or is too conservative.

Results: We propose a statistical method, JUMP, for the high-dimensional replicability analysis of two studies. The input is a high-dimensional paired sequence of p -values from two studies and the test statistic is the maximum of p -values of the pair. JUMP uses four states of the p -value pairs to indicate whether they are null or non-null. Conditional on the hidden states, JUMP computes the cumulative distribution function of the maximum of p -values for each state to conservatively approximate the probability of rejection under the composite null of replicability. JUMP estimates unknown parameters and uses a step-up procedure to control FDR. By incorporating different states of composite null, JUMP achieves a substantial power gain over existing methods while controlling the FDR. Analyzing two pairs of spatially resolved transcriptomic datasets, JUMP makes biological discoveries that otherwise cannot be obtained by using existing methods.

Availability: An R package JUMP implementing the JUMP method is available on CRAN (<https://CRAN.R-project.org/package=JUMP>).

Contact: hongyuancao@gmail.com

Supplementary information: Supplementary data are available at *Bioinformatics* online.

1 Introduction

Replicability is the cornerstone of modern scientific research. We study conceptual replicability, where consistent results are obtained from studies using different procedures and populations that target the same scientific questions. Replicability is related to but different from meta-analysis. Both approaches look at cross-experiment summaries. In a meta-analysis, the null hypothesis is that there is no effect in all studies. On the other hand, in replicability analysis, the alternative hypothesis is that the effects exist in all studies and the null hypothesis is a composite null, i.e., at least one study does not have an effect. Methods designed for meta-analysis, such as Fisher's method (Fisher, 1925), the Šidák's method (Šidák, 1967), the Lancaster's method (Lancaster, 1961) and the minimum of p -values are not applicable for replicability analysis.

We focus on the replicability analysis of genomic data produced by high-throughput experiments (Li et al., 2011; Phylstrom et al., 2018; Heng and Fithian, 2020; Bogomolov and Heller, 2022). In a high-throughput experiment, many candidates are evaluated for their association with a biological feature of interest, and those with significant associations are identified for further analysis. We aim to simultaneously identify replicable features from high-throughput experiments in multiple studies. To analyze a single high-throughput experiment, an acute problem is the multiple comparison. A classic method for multiple comparisons is the false discovery rate (FDR) control approach proposed in Benjamini and Hochberg (1995) (BH). The false discovery rate is defined as the expected value of the ratio of false rejections over total rejections. Suppose we have m hypotheses. The BH procedure works as follows. First, order p -values $p_{(1)} \leq \dots \leq p_{(m)}$. Second, find the largest i_0 such that $p_{(i_0)} \leq \alpha i_0 / m$. Third, reject hypotheses corresponding to $p_{(1)}, \dots, p_{(i_0)}$. Under the assumption that p -values from the null are independent and follow standard

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Fundamentals of Performance Evaluation of Computer and Telecommunication Systems Mohammed S. Obaidat, Nouredine A. Boudriga, 2010-01-26 The only singular all encompassing textbook on state of the art technical performance evaluation Fundamentals of Performance Evaluation of Computer and Telecommunication Systems uniquely presents all techniques of performance evaluation of computers systems communication networks and telecommunications in a balanced manner Written by the renowned Professor Mohammad S Obaidat and his coauthor Professor Nouredine Boudriga it is also the only resource to treat computer and telecommunication systems as inseparable issues The authors explain the basic concepts of performance evaluation applications performance evaluation metrics workload types benchmarking and characterization of workload This is followed by a review of the basics of probability theory and then the main techniques for performance evaluation namely measurement simulation and analytic modeling with case studies and examples Contains the practical and applicable knowledge necessary for a successful performance evaluation in a balanced approach Reviews measurement tools benchmark programs design of experiments traffic models basics of queueing theory and operational and mean value analysis Covers the techniques for validation and verification of simulation as well as random number generation random variate generation and testing with examples Features numerous examples and case studies as well as exercises and problems for use as homework or programming assignments Fundamentals of Performance Evaluation of Computer and Telecommunication Systems is an ideal textbook for graduate students in computer science electrical engineering computer engineering and information sciences technology and systems It is also an excellent reference for practicing engineers and scientists

The Mathematical-Function Computation Handbook Nelson H.F.

Beebe, 2017-08-20 This highly comprehensive handbook provides a substantial advance in the computation of elementary and special functions of mathematics extending the function coverage of major programming languages well beyond their international standards including full support for decimal floating point arithmetic Written with clarity and focusing on the C language the work pays extensive attention to little understood aspects of floating point and integer arithmetic and to software portability as well as to important historical architectures It extends support to a future 256 bit floating point format offering 70 decimal digits of precision Select Topics and Features references an exceptionally useful author maintained MathCW website containing source code for the book s software compiled libraries for numerous systems pre built C compilers and other related materials offers a unique approach to covering mathematical function computation using decimal arithmetic provides extremely versatile appendices for interfaces to numerous other languages Ada C C Fortran Java and Pascal presupposes only basic familiarity with computer programming in a common language as well as early level algebra supplies a library that readily adapts for existing scripting languages with minimal effort supports both binary and decimal arithmetic in up to 10 different floating point formats covers a significant portion with highly accurate

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The Oxford Handbook of Quantitative Methods, Vol. 2: Statistical Analysis Todd D. Little, 2013-02-01 Research today demands the application of sophisticated and powerful research tools Fulfilling this need The Oxford Handbook of Quantitative Methods is the complete tool box to deliver the most valid and generalizable answers to today's complex research questions It is a one stop source for learning and reviewing current best practices in quantitative methods as practiced in the social behavioral and educational sciences Comprising two volumes this handbook covers a wealth of topics related to quantitative research methods It begins with essential philosophical and ethical issues related to science and quantitative research It then addresses core measurement topics before delving into the design of studies Principal issues related to modern estimation and mathematical modeling are also detailed Topics in the handbook then segway into the realm of statistical inference and modeling with chapters dedicated to classical approaches as well as modern latent variable approaches Numerous chapters associated with longitudinal data and more specialized techniques round out this broad selection of topics Comprehensive authoritative and user friendly this two volume set will be an indispensable resource for serious researchers across the social behavioral and educational sciences

Parallel Scientific Computation Rob H. Bisseling, 2020 Parallel Scientific Computation presents a methodology for designing parallel algorithms and writing parallel computer programs for modern computer architectures with multiple processors

Assessment of Treatment Plant Performance and Water Quality Data: A Guide for Students, Researchers and Practitioners Marcos von Sperling ,Matthew E. Verbyla ,Silvia M.A.C Oliveira, 2020-01-15 This book presents the basic principles for evaluating water quality and treatment plant performance in a clear innovative and didactic way using a combined approach that involves the interpretation of monitoring data associated with i the basic processes that take place in water bodies and in water and wastewater treatment plants and ii data management and statistical calculations to allow a deep interpretation of the data This book is problem oriented and works from practice to theory covering most of the information you will need such as a obtaining flow data and working with the concept of loading b organizing sampling programmes and measurements c connecting laboratory analysis to data management e using numerical and graphical methods for describing monitoring data descriptive statistics f understanding and reporting removal efficiencies g recognizing symmetry and asymmetry in monitoring data normal and log normal distributions h evaluating compliance with targets and regulatory standards for effluents and water bodies i making comparisons with the monitoring data tests of hypothesis j understanding the relationship between monitoring variables correlation and regression analysis k making water

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Energy and Water Development Appropriations for 2015: Department of Energy: Secretary of Energy United States. Congress. House. Committee on Appropriations. Subcommittee on Energy and Water Development, 2014

Life-Cycle Performance of Structures and Infrastructure Systems in Diverse Environments Chun-Qing Li, Dan M. Frangopol, 2025-07-14 *Life Cycle Performance of Structures and Infrastructure Systems in Diverse Environments* contains the lectures and papers presented at the Ninth International Symposium on Life Cycle Civil Engineering IALCCE 2025 Melbourne Australia 15-19 July 2025 This book includes the full papers of 228 contributions presented at IALCCE 2025 including the Fazlur R Khan Lecture seven Keynote Lectures and 220 technical papers The papers cover recent advances and cutting edge research in the field of life cycle civil engineering including emerging concepts new theories and innovative applications related to life cycle design assessment inspection monitoring repair maintenance rehabilitation and management of structures and infrastructure systems under uncertainty Major topics covered include life cycle carbon assessment of civil infrastructure systems life cycle design and assessment for structures and infrastructure systems life cycle management of civil infrastructure whole life costing life cycle risk analysis and optimization of civil infrastructure and life cycle digital tools for civil engineering among others This open access book provides both an up to date overview of the field of life cycle civil engineering and significant contributions to the process of making more rational decisions to mitigate the life cycle risk and improve the life cycle safety reliability resilience and sustainability of structures and infrastructure systems exposed to diverse environments in a changing climate for the purpose of enhancing the welfare of society It will serve as a valuable reference to all concerned with life cycle of civil engineering systems including students researchers practitioners consultants contractors decision makers and representatives of managing bodies and public authorities from all branches of civil engineering

Scientific and Technical Aerospace Reports, 1991 *Theoretical Models and Experimental Approaches in Physical Chemistry* A. K. Haghi, Sabu Thomas, Praveen K.M., Avinash R. Pai, 2018-10-01 This new volume presents an up to date review of modern materials and physical chemistry concepts issues and recent advances in the field It presents a modern theoretical and experimental approach in applied physical chemistry The volume discusses the developments of advanced chemical products and respective tools to characterize and predict the chemical material properties and behavior With chapters from distinguished scientists and engineers from key institutions worldwide the volume provides understanding through numerous examples and practical applications drawn from research and

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Textbook of Hepatology Juan Rodés, Jean-Pierre Benhamou, Andres Blei, Juerg Reichen, Mario Rizzetto, Jean-Francois Dufour, Scott L. Friedman, Pere Ginès, Dominique-Charles Valla, Fabien Zoulim, 2008-04-15 THE encyclopedic guide to hepatology for consultation by clinicians and basic scientists Previously the Oxford Textbook of Clinical Hepatology this two volume textbook is now with Blackwell Publishing It covers basic clinical and translational science converting basic science discoveries into the practical applications to benefit people Edited by ten leading experts in the liver and biliary tract and their diseases along with outstanding contributions from over 200 international clinicians this text has global references evidence and extensive subject matter giving you the best science and clinical practice discussed by the best authors It includes unique sections on Symptoms and signs in liver disease Industrial diseases affecting the liver The effects of diseases of other systems on the liver The effects of liver diseases on other systems It s bigger and more extensive than other books and discusses new areas in more depth such as stem cells genetics genomics proteomics transplantation mathematics and much more Plus it comes with a fully searchable CD ROM of the entire content Click here to view a sample chapter on the liver and coagulation

X-Ray Absorption Fine Structure -- XAFS13 Britt Hedman, Piero Pianetta, 2007-03-09 Stanford California USA 9 14 July 2006

Evaluating Performance Michele Biasutti, George Waddell, Aaron Williamon, Roberta Antonini Philippe, 2023-10-19

Cognitive Benefits of Technologies Applied to Learning in Education Beatriz Peña-Acuña, Yolanda Navarro Abal, Pedro Román-Graván, Pedro Tadeu, Manuel León-Urrutia, Javier Ávila-López ,Rafael Crismán Crismán Pérez, Carmen M. Toscano-Fuentes, Carmen María Martín Del Pino, 2025-03-12 In general scientific inquiry about the benefits of digital gadgets focused on learning at all stages of Education is providing cognitive affective and attitudinal variables However cognitive effects stand out among these effects In this topic of inquiry that we propose we intend to investigate the phenomenon from a simple discipline to a multidisciplinary point of view that is from interventions that work transversally on some transversal theme in different disciplines or with a review approach from various points of view We also propose it to deepen the phenomenon with interventions that are investigated from an interdisciplinary perspective taking into account the qualitative and or quantitative study of a variable from one discipline and another variable from another discipline Likewise other studies of the cognitive effects of technologies in learning with paradigms or innovative approaches and evaluation of more complex interventions can be considered We are in a moment of transition from the use of analogue materials to digital tools

platforms applications gadgets tablets mobiles etc and advanced technology formats immersive realities and artificial intelligence This is a moment of technological transformation in which the benefits of new technologies in learning are beginning to be investigated both in interventions with grouping in individual perspective or in an interactive and collaborative perspective among equals It also coincides with the development of neuroscience and psychology applied to Education This research topic aims to contribute to deepen this topic and provide a global vision It also intends to indicate to what extent the development of the cognitive is relevant as well as to extend the variables that must be considered

Computer Program Abstracts ,1975 5G Multimedia Communication Zoran S. Bojkovic,Dragorad A.

Milovanovic,Tulsi Pawan Fowdur,2020-10-27 In bringing to the readers the book 5G Multimedia Communication Technology Multiservices and Deployment the aim is to present current work and direction on the challenging subject of multimedia communications with theoretical and practical roots The past two decades have witnessed an extremely fast evolution of mobile cellular network technology The fifth generation of mobile wireless systems has achieved the first milestone toward finalization and deployment by 2020 This is vital to the development of future multimedia communications Also it is necessary to consider 5G technology from the performance point of view by analyzing network capabilities to the operator and to the end user in terms of data rate capacity coverage energy efficiency connectivity and latency The book is divided into three major parts with each part containing four to seven chapters Critical enabling technology Multiservices network Deployment scenarios The first part discusses enabling technologies such as green communication channel modeling massive and distributed MIMO and ML based networks In the second part different methodologies and standards for multiservices have been discussed Exclusive chapters have been dedicated to each of the open research challenges such as multimedia operating in 5G environment network slicing optimization mobile edge computing mobile video multicast broadcast integrated satellite and drone communication The third part paved the way to deployment scenarios for different innovative services including integration of a multienergy system in smart cities intelligent transportation systems 5G connectivity in the transport sector healthcare services 5G edge based video surveillance and challenges of connectivity for massive IoT in 5G and beyond systems The book is written by experts in the field who introduced scientific and engineering concepts covering the 5G multimedia communication areas The book can be read cover to cover or selectively in the areas of interest for the readers Generally the book is intended for novel readers who could benefit from understanding general concepts practitioners who seek guidance into the field and senior level as well as graduate level engineering students in understanding the process of today s wireless multimedia communications **Network Bioscience, 2nd Edition** Marco Pellegrini,Marco Antoniotti,Bud Mishra,2020-03-27 Network science has accelerated a deep and successful trend in research that influences a range of disciplines like mathematics graph theory physics statistics data science and computer science just to name a few and adapts the relevant techniques and insights to address relevant but disparate social biological

technological questions We are now in an era of big biological data supported by cost effective high throughput genomic transcriptomic proteomic metabolomic data collection techniques that allow one to take snapshots of the cells molecular profiles in a systematic fashion Moreover recently also phenotypic data data on diseases symptoms patients etc are being collected at nation wide level thus giving us another source of highly related causal big data This wealth of data is usually modeled as networks aka binary relations graphs or webs of interactions including protein protein metabolic signaling and transcription regulatory interactions The network model is a key view point leading to the uncovering of mesoscale phenomena thus providing an essential bridge between the observable phenotypes and omics underlying mechanisms Moreover network analysis is a powerful hypothesis generation tool guiding the scientific cycle of data gathering data interpretation hypothesis generation and hypothesis testing A major challenge in contemporary research is the synthesis of deep insights coming from network science with the wealth of data often noisy contradictory incomplete and difficult to replicate so to answer meaningful biological questions in a quantifiable way using static and dynamic properties of biological networks

Recent Advances in Cardiotoxicity Testing Tamer M. A. Mohamed, Javid Moslehi, Jonathan Satin, 2022-01-05

Safety and performance concepts contributions to the workshop sessions model uncertainties new concepts and full scale testing FIB - International Federation for Structural Concrete, 1993-08-01 Shiphandling Simulation National Research Council, Division on Engineering and Physical Sciences, Commission on Engineering and Technical Systems, Marine Board, Committee on Assessment of Shiphandling Simulation, 1992-02-01 As a result of major shipping disasters on all coasts the safety of vessel operations in U S ports and waterways and the effectiveness of waterway designs are under increased scrutiny But are traditional waterway design practices that rely heavily on rules of thumb and conservatism providing adequate margins of safety while keeping the overall costs of waterway projects within the funding capabilities of local project sponsors Shiphandling Simulation addresses how computer based simulation can be used to improve the cost effectiveness of waterway design while satisfying safety objectives The book examines the role of computer simulation in improving waterway design evaluates the adequacy of data input explores the validity of hydrodynamic and mathematical models assesses required and achievable accuracy of simulation results and identifies research needed to establish shiphandling simulation as a standard design aid Case studies of waterway design efforts employing shiphandling simulation are analyzed and lessons learned are identified

Common Rail Fuel Injection Technology in Diesel Engines Guangyao Ouyang, Shijie An, Zhenming Liu, Yuxue Li, 2019-04-08 A wide ranging and practical handbook that offers comprehensive treatment of high pressure common rail technology for students and professionals In this volume Dr Ouyang and his colleagues answer the need for a comprehensive examination of high pressure common rail systems for electronic fuel injection technology a crucial element in the optimization of diesel engine efficiency and emissions The text begins with an overview of common rail systems today including a look back at their progress since the 1970s and an examination of

recent advances in the field It then provides a thorough grounding in the design and assembly of common rail systems with an emphasis on key aspects of their design and assembly as well as notable technological innovations This includes discussion of advancements in dual pressure common rail systems and the increasingly influential role of Electronic Control Unit ECU technology in fuel injector systems The authors conclude with a look towards the development of a new type of common rail system Throughout the volume concepts are illustrated using extensive research experimental studies and simulations Topics covered include Comprehensive detailing of common rail system elements elementary enough for newcomers and thorough enough to act as a useful reference for professionals Basic and simulation models of common rail systems including extensive instruction on performing simulations and analyzing key performance parameters Examination of the design and testing of next generation twin common rail systems including applications for marine diesel engines Discussion of current trends in industry research as well as areas requiring further study Common Rail Fuel Injection Technology is the ideal handbook for students and professionals working in advanced automotive engineering particularly researchers and engineers focused on the design of internal combustion engines and advanced fuel injection technology Wide ranging research and ample examples of practical applications will make this a valuable resource both in education and private industry

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Table of Contents Pdf Analysis Throughput Experiments Mathematical Computational

1. Understanding the eBook Pdf Analysis Throughput Experiments Mathematical Computational
 - The Rise of Digital Reading Pdf Analysis Throughput Experiments Mathematical Computational
 - Advantages of eBooks Over Traditional Books
2. Identifying Pdf Analysis Throughput Experiments Mathematical Computational
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Pdf Analysis Throughput Experiments Mathematical Computational
 - User-Friendly Interface
4. Exploring eBook Recommendations from Pdf Analysis Throughput Experiments Mathematical Computational
 - Personalized Recommendations
 - Pdf Analysis Throughput Experiments Mathematical Computational User Reviews and Ratings
 - Pdf Analysis Throughput Experiments Mathematical Computational and Bestseller Lists

5. Accessing Pdf Analysis Throughput Experiments Mathematical Computational Free and Paid eBooks
 - Pdf Analysis Throughput Experiments Mathematical Computational Public Domain eBooks
 - Pdf Analysis Throughput Experiments Mathematical Computational eBook Subscription Services
 - Pdf Analysis Throughput Experiments Mathematical Computational Budget-Friendly Options
6. Navigating Pdf Analysis Throughput Experiments Mathematical Computational eBook Formats
 - ePub, PDF, MOBI, and More
 - Pdf Analysis Throughput Experiments Mathematical Computational Compatibility with Devices
 - Pdf Analysis Throughput Experiments Mathematical Computational Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Pdf Analysis Throughput Experiments Mathematical Computational
 - Highlighting and Note-Taking Pdf Analysis Throughput Experiments Mathematical Computational
 - Interactive Elements Pdf Analysis Throughput Experiments Mathematical Computational
8. Staying Engaged with Pdf Analysis Throughput Experiments Mathematical Computational
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Pdf Analysis Throughput Experiments Mathematical Computational
9. Balancing eBooks and Physical Books Pdf Analysis Throughput Experiments Mathematical Computational
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Pdf Analysis Throughput Experiments Mathematical Computational
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Pdf Analysis Throughput Experiments Mathematical Computational
 - Setting Reading Goals Pdf Analysis Throughput Experiments Mathematical Computational
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Pdf Analysis Throughput Experiments Mathematical Computational
 - Fact-Checking eBook Content of Pdf Analysis Throughput Experiments Mathematical Computational
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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