

Algorithms
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Dmitry Kozlov

Combinatorial Algebraic Topology



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Combinatorial Algebraic Topology Algorithms And Computation In Mathematics

Michael Joswig



Combinatorial Algebraic Topology Algorithms And Computation In Mathematics:

Combinatorial Algebraic Topology Dmitry Kozlov, 2008-01-08 This volume is the first comprehensive treatment of combinatorial algebraic topology in book form The first part of the book constitutes a swift walk through the main tools of algebraic topology Readers graduate students and working mathematicians alike will probably find particularly useful the second part which contains an in depth discussion of the major research techniques of combinatorial algebraic topology Although applications are sprinkled throughout the second part they are principal focus of the third part which is entirely devoted to developing the topological structure theory for graph homomorphisms [Connection Matrices in Combinatorial Topological Dynamics](#) Marian Mrozek, Thomas Wanner, 2025-07-08 This book provides an introduction to the theory of connection matrices in the context of combinatorial multivector fields The theory of connection matrices was proposed by Conley and Franzosa for classical continuous time dynamical systems as a tool for studying connecting orbits between isolated invariant sets It generalizes the Morse complex in Morse theory and has found numerous applications in dynamics Connection matrices have been and still are a challenging topic to study as there are no complete introductory texts and both their intricate definition and properties are scattered over numerous research papers In recent years dynamical concepts have found their way into a combinatorial context Starting with combinatorial vector fields introduced by Forman to generalize classical Morse theory it has been realized that this transfer of ideas can lead to important applications Similarly Conley s theory of isolated invariant sets has been transferred to the combinatorial setting This when combined with the concept of multivector fields opens the door to a complete combinatorial dynamical theory In this book we take Conley s theory one step further by presenting a complete discussion of connection matrices for combinatorial multivector fields While some of the results in this book are based on known approaches we show in a detailed way how they can be carried over to the case of multivector fields on general Lefschetz complexes Along the way we introduce notions which are new even in the classical setting such as a formal approach to addressing the nonuniqueness of connection matrices as well as mechanisms for comparing connection matrices even under poset changes Finally we show that specifically for the case of Forman s gradient combinatorial vector fields connection matrices are necessarily unique and can be determined explicitly in a straightforward way Focusing on the combinatorial theory of connection matrices has a number of advantages On the one hand many of the technical difficulties of the classical continuous time dynamics situation are not present in the discrete combinatorial context This allows us to provide a complete and informal introduction to the theory in the second section of the book This in turn will enable the readers to construct and analyze their own examples easily On the other hand the complete theory including the existence of connecting orbits in the combinatorial setting can be presented in detail based on an explicit distinction between the algebraic and topological parts of the theory In this way it is our hope that this book will be an impetus for further knowledge transfer between dynamics and combinatorics and even topological data analysis This

text is aimed at researchers in the fields of dynamics and topological data analysis and it is suitable for advanced graduate students interested in applying connection matrix methods to their own studies

Directed Algebraic Topology and Concurrency Lisbeth Fajstrup, Eric Goubault, Emmanuel Haucourt, Samuel Mimram, Martin Raussen, 2016-03-02 This monograph presents an application of concepts and methods from algebraic topology to models of concurrent processes in computer science and their analysis Taking well known discrete models for concurrent processes in resource management as a point of departure the book goes on to refine combinatorial and topological models In the process it develops tools and invariants for the new discipline directed algebraic topology which is driven by fundamental research interests as well as by applications primarily in the static analysis of concurrent programs The state space of a concurrent program is described as a higher dimensional space the topology of which encodes the essential properties of the system In order to analyse all possible executions in the state space more than just the topological properties have to be considered Execution paths need to respect a partial order given by the time flow As a result tools and concepts from topology have to be extended to take privileged directions into account The target audience for this book consists of graduate students researchers and practitioners in the field mathematicians and computer scientists alike

Algebraic Foundations for Applied Topology and Data Analysis Hal Schenck, 2022-11-21 This book gives an intuitive and hands on introduction to Topological Data Analysis TDA Covering a wide range of topics at levels of sophistication varying from elementary matrix algebra to esoteric Grothendieck spectral sequence it offers a mirror of data science aimed at a general mathematical audience The required algebraic background is developed in detail The first third of the book reviews several core areas of mathematics beginning with basic linear algebra and applications to data fitting and web search algorithms followed by quick primers on algebra and topology The middle third introduces algebraic topology along with applications to sensor networks and voter ranking The last third covers key contemporary tools in TDA persistent and multiparameter persistent homology Also included is a user s guide to derived functors and spectral sequences useful but somewhat technical tools which have recently found applications in TDA and an appendix illustrating a number of software packages used in the field Based on a course given as part of a masters degree in statistics the book is appropriate for graduate students

Research in Computational Topology 2 Ellen Gasparovic, Vanessa Robins, Katharine Turner, 2022-05-10 This second volume of Research in Computational Topology is a celebration and promotion of research by women in applied and computational topology containing the proceedings of the second workshop for Women in Computational Topology WinCompTop as well as papers solicited from the broader WinCompTop community The multidisciplinary and international WinCompTop workshop provided an exciting and unique opportunity for women in diverse locations and research specializations to interact extensively and collectively contribute to new and active research directions in the field The prestigious senior researchers that signed on to head projects at the workshop are global leaders in the discipline and two of them were authors on some of the first papers in the field Some of

the featured topics include topological data analysis of power law structure in neural data a nerve theorem for directional graph covers topological or homotopical invariants for directed graphs encoding connections among a network of neurons and the issue of approximation of objects by digital grids including precise relations between the persistent homology of dual cubical complexes

An Invitation to Computational Homotopy Graham Ellis, 2019 An Invitation to Computational Homotopy is an introduction to elementary algebraic topology for those with an interest in computers and computer programming It expertly illustrates how the basics of the subject can be implemented on a computer through its focus on fully worked examples designed to develop problem solving techniques The transition from basic theory to practical computation raises a range of non trivial algorithmic issues which will appeal to readers already familiar with basic theory and who are interested in developing computational aspects The book covers a subset of standard introductory material on fundamental groups covering spaces homology cohomology and classifying spaces as well as some less standard material on crossed modules These topics are covered in a way that hints at potential applications of topology in areas of computer science and engineering outside the usual territory of pure mathematics and also in a way that demonstrates how computers can be used to perform explicit calculations within the domain of pure algebraic topology itself The initial chapters include in depth examples from data mining biology and digital image analysis while the later chapters cover a range of computational examples on the cohomology of classifying spaces that are likely beyond the reach of a purely paper and pen approach to the subject An Invitation to Computational Homotopy serves as a self contained and informal introduction to these topics and their implementation in the sphere of computer science Written in a dynamic and engaging style it skilfully showcases a range of useful machine computations and will serve as an invaluable aid to graduate students working with algebraic topology

The Mathematics of Data Michael W. Mahoney, John C. Duchi, Anna C. Gilbert, 2018-11-15 Nothing provided

Pattern Recognition on Oriented Matroids Andrey O. Matveev, 2017-09-11 Pattern Recognition on Oriented Matroids covers a range of innovative problems in combinatorics poset and graph theories optimization and number theory that constitute a far reaching extension of the arsenal of committee methods in pattern recognition The groundwork for the modern committee theory was laid in the mid 1960s when it was shown that the familiar notion of solution to a feasible system of linear inequalities has ingenious analogues which can serve as collective solutions to infeasible systems A hierarchy of dialects in the language of mathematics for instance open cones in the context of linear inequality systems regions of hyperplane arrangements and maximal covectors or topes of oriented matroids provides an excellent opportunity to take a fresh look at the infeasible system of homogeneous strict linear inequalities the standard working model for the contradictory two class pattern recognition problem in its geometric setting The universal language of oriented matroid theory considerably simplifies a structural and enumerative analysis of applied aspects of the infeasibility phenomenon The present book is devoted to several selected topics in the emerging theory of pattern recognition on oriented matroids the

questions of existence and applicability of matroidal generalizations of committee decision rules and related graph theoretic constructions to oriented matroids with very weak restrictions on their structural properties a study in which in particular interesting subsequences of the Farey sequence appear naturally of the hierarchy of the corresponding tope committees a description of the three tope committees that are the most attractive approximation to the notion of solution to an infeasible system of linear constraints an application of convexity in oriented matroids as well as blocker constructions in combinatorial optimization and in poset theory to enumerative problems on tope committees an attempt to clarify how elementary changes one element reorientations in an oriented matroid affect the family of its tope committees a discrete Fourier analysis of the important family of critical tope committees through rank and distance relations in the tope poset and the tope graph the characterization of a key combinatorial role played by the symmetric cycles in hypercube graphs Contents Oriented Matroids the Pattern Recognition Problem and Tope Committees Boolean Intervals Dehn Sommerville Type Relations Farey Subsequences Blocking Sets of Set Families and Absolute Blocking Constructions in Posets Committees of Set Families and Relative Blocking Constructions in Posets Layers of Tope Committees Three Tope Committees Halfspaces Convex Sets and Tope Committees Tope Committees and Reorientations of Oriented Matroids Topes and Critical Committees Critical Committees and Distance Signals Symmetric Cycles in the Hypercube Graphs Organized Collapse: An Introduction to Discrete Morse Theory Dmitry N. Kozlov, 2021-02-18 Applied topology is a modern subject which emerged in recent years at a crossroads of many methods all of them topological in nature which were used in a wide variety of applications in classical mathematics and beyond Within applied topology discrete Morse theory came into light as one of the main tools to understand cell complexes arising in different contexts as well as to reduce the complexity of homology calculations The present book provides a gentle introduction into this beautiful theory Using a combinatorial approach the author emphasizes acyclic matchings as the central object of study The first two parts of the book can be used as a stand alone introduction to homology the last two parts delve into the core of discrete Morse theory The presentation is broad ranging from abstract topics such as formulation of the entire theory using poset maps with small fibers to heavily computational aspects providing for example a specific algorithm of finding an explicit homology basis starting from an acyclic matching The book will be appreciated by graduate students in applied topology students and specialists in computer science and engineering as well as research mathematicians interested in learning about the subject and applying it in context of their fields Handbook of Homotopy Theory Haynes Miller, 2020-01-23 The Handbook of Homotopy Theory provides a panoramic view of an active area in mathematics that is currently seeing dramatic solutions to long standing open problems and is proving itself of increasing importance across many other mathematical disciplines The origins of the subject date back to work of Henri Poincaré and Heinz Hopf in the early 20th century but it has seen enormous progress in the 21st century A highlight of this volume is an introduction to and diverse applications of the newly established foundational theory of categories The coverage is vast

ranging from axiomatic to applied from foundational to computational and includes surveys of applications both geometric and algebraic The contributors are among the most active and creative researchers in the field The 22 chapters by 31 contributors are designed to address novices as well as established mathematicians interested in learning the state of the art in this field whose methods are of increasing importance in many other areas

Simplicial Complexes In Complex Systems: In Search For Alternatives Yi Zhao, Slobodan Maletic, 2021-05-25 For the last few decades researchers from different fields gather their findings and knowledge trying to give a shape to the new science of complex systems To address this problem new tools and methods have to be established A new or more precisely an alternative framework for the characterization of complex system was proposed In this book we will introduce the applicability of applicability of simplicial complexes in the science of complex systems After introducing the main definitions and properties of simplicial complexes necessary for representation and analysis of complex systems we will illustrate the usefulness and versatility of tools and concepts related to the simplicial complexes

Essentials of Tropical Combinatorics Michael Joswig, 2021-12-08 The goal of this book is to explain at the graduate student level connections between tropical geometry and optimization Building bridges between these two subject areas is fruitful in two ways Through tropical geometry optimization algorithms become applicable to questions in algebraic geometry Conversely looking at topics in optimization through the tropical geometry lens adds an additional layer of structure The author covers contemporary research topics that are relevant for applications such as phylogenetics neural networks combinatorial auctions game theory and computational complexity This self contained book grew out of several courses given at Technische Universit t Berlin and elsewhere and the main prerequisite for the reader is a basic knowledge in polytope theory It contains a good number of exercises many examples beautiful figures as well as explicit tools for computations using texttt polymake

Bimonoids for Hyperplane Arrangements Marcelo Aguiar, Swapneel Mahajan, 2020-03-19 The goal of this monograph is to develop Hopf theory in a new setting which features centrally a real hyperplane arrangement The new theory is parallel to the classical theory of connected Hopf algebras and relates to it when specialized to the braid arrangement Joyal s theory of combinatorial species ideas from Tits theory of buildings and Rota s work on incidence algebras inspire and find a common expression in this theory The authors introduce notions of monoid comonoid bimonoid and Lie monoid relative to a fixed hyperplane arrangement They also construct universal bimonoids by using generalizations of the classical notions of shuffle and quasishuffle and establish the Borel Hopf Poincar Birkhoff Witt and Cartier Milnor Moore theorems in this setting This monograph opens a vast new area of research It will be of interest to students and researchers working in the areas of hyperplane arrangements semigroup theory Hopf algebras algebraic Lie theory operads and category theory

Elementary Theory of Groups and Group Rings, and Related Topics Paul Baginski, Benjamin Fine, Anja Moldenhauer, Gerhard Rosenberger, Vladimir Shpilrain, 2020-02-10 This proceedings volume documents the contributions presented at the conference held at Fairfield University and at the

Graduate Center CUNY in 2018 celebrating the New York Group Theory Seminar in memoriam Gilbert Baumslag and to honor Benjamin Fine and Anthony Gaglione It includes several expert contributions by leading figures in the group theory community and provides a valuable source of information on recent research developments

Discrete Morse Theory

Nicholas A. Scoville, 2019-09-27 Discrete Morse theory is a powerful tool combining ideas in both topology and combinatorics Invented by Robin Forman in the mid 1990s discrete Morse theory is a combinatorial analogue of Marston Morse's classical Morse theory Its applications are vast including applications to topological data analysis combinatorics and computer science This book the first one devoted solely to discrete Morse theory serves as an introduction to the subject Since the book restricts the study of discrete Morse theory to abstract simplicial complexes a course in mathematical proof writing is the only prerequisite needed Topics covered include simplicial complexes simple homotopy collapsibility gradient vector fields Hasse diagrams simplicial homology persistent homology discrete Morse inequalities the Morse complex discrete Morse homology and strong discrete Morse functions Students of computer science will also find the book beneficial as it includes topics such as Boolean functions evasiveness and has a chapter devoted to some computational aspects of discrete Morse theory The book is appropriate for a course in discrete Morse theory a supplemental text to a course in algebraic topology or topological combinatorics or an independent study

Complex Networks & Their Applications XIII

Hocine Cherifi, Murat Donduran, Luis M. Rocha, Chantal Cherifi, Onur Varol, 2025-03-28 This book highlights cutting edge research in network science offering scientists researchers students and practitioners a unique update on the latest advances in theory and a multitude of applications It presents the peer reviewed proceedings of the XIII International Conference on Complex Networks and their Applications COMPLEX NETWORKS 2024 The carefully selected papers cover a wide range of theoretical topics such as network embedding and network geometry community structure network dynamics diffusion epidemics and spreading processes machine learning and graph neural networks as well as all the main network applications including social and political networks networks in finance and economics biological networks and technological networks

Graph Theory Beril Sirmacek, 2018-01-31 This book is prepared as a combination of the manuscripts submitted by respected mathematicians and scientists around the world As an editor I truly enjoyed reading each manuscript Not only will the methods and explanations help you to understand more about graph theory but I also hope you will find it joyful to discover ways that you can apply graph theory in your scientific field I believe the book can be read from the beginning to the end at once However the book can also be used as a reference guide in order to turn back to it when it is needed I have to mention that this book assumes the reader to have a basic knowledge about graph theory The very basics of the theory and terms are not explained at the beginner level I hope this book will support many applied and research scientists from different scientific fields

Distributed Computing Through Combinatorial Topology Maurice Herlihy, Dmitry Kozlov, Sergio Rajsbaum, 2013-11-30 Distributed Computing Through Combinatorial Topology describes techniques for analyzing distributed

algorithms based on award winning combinatorial topology research The authors present a solid theoretical foundation relevant to many real systems reliant on parallelism with unpredictable delays such as multicore microprocessors wireless networks distributed systems and Internet protocols Today a new student or researcher must assemble a collection of scattered conference publications which are typically terse and commonly use different notations and terminologies This book provides a self contained explanation of the mathematics to readers with computer science backgrounds as well as explaining computer science concepts to readers with backgrounds in applied mathematics The first section presents mathematical notions and models including message passing and shared memory systems failures and timing models The next section presents core concepts in two chapters each first proving a simple result that lends itself to examples and pictures that will build up readers intuition then generalizing the concept to prove a more sophisticated result The overall result weaves together and develops the basic concepts of the field presenting them in a gradual and intuitively appealing way The book s final section discusses advanced topics typically found in a graduate level course for those who wish to explore further Named a 2013 Notable Computer Book for Computing Methodologies by Computing Reviews Gathers knowledge otherwise spread across research and conference papers using consistent notations and a standard approach to facilitate understanding Presents unique insights applicable to multiple computing fields including multicore microprocessors wireless networks distributed systems and Internet protocols Synthesizes and distills material into a simple unified presentation with examples illustrations and exercises *Arrangements, Local Systems and Singularities* Fouad El Zein,Alexander I. Suciu,Meral Tosun,Muhammed Uludag,Sergey Yuzvinsky,2010-03-14 This volume comprises the Lecture Notes of the CIMPA TUBITAK Summer School Arrangements Local systems and Singularities held at Galatasaray University Istanbul during June 2007 The volume is intended for a large audience in pure mathematics including researchers and graduate students working in algebraic geometry singularity theory topology and related fields The reader will find a variety of open problems involving arrangements local systems and singularities proposed by the lecturers at the end of the school

Thirty Essays on Geometric Graph Theory János Pach,2012-12-15 In many applications of graph theory graphs are regarded as geometric objects drawn in the plane or in some other surface The traditional methods of abstract graph theory are often incapable of providing satisfactory answers to questions arising in such applications In the past couple of decades many powerful new combinatorial and topological techniques have been developed to tackle these problems Today geometric graph theory is a burgeoning field with many striking results and appealing open questions This contributed volume contains thirty original survey and research papers on important recent developments in geometric graph theory The contributions were thoroughly reviewed and written by excellent researchers in this field

Reviewing **Combinatorial Algebraic Topology Algorithms And Computation In Mathematics**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is actually astonishing. Within the pages of "**Combinatorial Algebraic Topology Algorithms And Computation In Mathematics**," an enthralling opus penned by a highly acclaimed wordsmith, readers set about an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve in to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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