This book constitutes the thoroughly refereed post-conference proceedings of the 20th International Workshop on Multi-Agent-Based Simulation, MABS 2019, held in Montreal, QC, Canada, in May 2019 as part of the AAMAS 2019, the 18th International Conference on Autonomous Agents and Multiagent Systems. The 9 revised full papers included in this volume were carefully selected from 15 submissions. They focus on finding efficient solutions to model complex social systems in such areas as economics, management, and organisational and social sciences. In all these areas, agent theories, metaphors, models, analysis, experimental designs, empirical studies, and methodological principles, converge into simulation as a way of achieving explanations and predictions, exploration and testing of hypotheses, better designs and systems.

Visualization research aims to provide insight into large, complicated data sets and the phenomena behind them. While there are different methods of reaching this goal, topological methods stand out for their solid mathematical foundation, which guides the algorithmic analysis and its presentation. Topology-based methods in visualization have been around since the beginning of visualization as a scientific discipline, but they initially played only a minor role. In recent years, interest in topology-based visualization has grown significantly, leading to new concepts and successful applications. The latest trends adapt basic topological concepts to precisely express user interests in topological properties of the data. This book is the outcome of the second workshop on Topological Methods in Visualization, which was held March 4–6, 2007 in Kloster Nimbshen near Leipzig, Germany. The workshop brought together more than 40 international researchers to present and discuss the state of the art and new trends in the field of topology-based visualization. Two inspiring invited talks by George Haller, MIT, and Nelson Max, LLNL, were accompanied by 14 presentations by participants and two panel discussions on current and future trends in visualization research. This book contains thirteen research papers that have been peer-reviewed in a two-stage review process. In the first stage, submitted papers were peer-reviewed by the international program committee. After the workshop accepted papers went through a revision and a second review process, taking into account comments from the first round, and discussions at the workshop. About half the papers concern topology-based analysis and visualization of fluid flow simulations, while the remaining papers discuss topology-based visualization methods in application areas like biology, medical imaging and electromagnetism.

This book contains papers presented at the Workshop on the Analysis of Large-scale, High-Dimensional, and Multi-Variate Data Using Topology and Statistics, held in Le Barp, France, June 2013. It features the work of some of the most prominent and recognized leaders in the field who examine challenges as well as detailed solutions to the analysis of complex data. The book presents new methods that leverage the mutual strengths of both topological and statistical techniques to support the management, analysis, and visualization of complex data. It covers both theory and application and provides readers with an overview of important key concepts and the latest research trends. Coverage in the book includes multi-variate and/or high-dimensional analysis techniques, feature-based statistical methods, combinatorial algorithms, scalable statistics algorithms, scalar and vector field topology, and multi-scale representations. In addition, the book details algorithms that are broadly applicable and can be used by application scientists to glean insight from a wide range of complex data sets.

Topological Methods for Differential Equations and Inclusions covers the important topics involving topological methods in the theory of systems of differential equations. The equivalence between a control system and the corresponding differential inclusion is the central idea used to prove existence theorems in optimal control theory. Since the dynamics of economic, social, and biological systems are multi-valued, differential inclusions serve as natural models in macro systems with hysteresis.

This book is a result of a workshop, the 8th of the successful TopoInVis workshop series, held in 2019 in Nyköping, Sweden. The workshop regularly gathers some of the world’s leading experts in this field. Thereby, it provides a forum for discussions on the latest advances in the field with a focus on finding practical solutions to open problems in topological data analysis for visualization. The contributions provide introductory and novel research articles including new concepts for the analysis of multivariate and time-dependent data, robust computational approaches for the extraction and approximations of topological structures with theoretical guarantees, and applications of topological scalar and vector field analysis for visualization. The applications span a wide range of scientific areas comprising climate science, material sciences, fluid dynamics, and astronomy. In addition, community efforts with respect to joint software development are reported and discussed.

Combining theoretical and practical aspects of topology, this book provides a comprehensive and self-contained introduction to topological methods for the analysis and visualization of scientific data. Theoretical concepts are presented in a painstaking but intuitive manner, with numerous high-quality color illustrations. Key algorithms for the computation and simplification of topological data representations are described in detail, and their application is carefully demonstrated in a chapter dedicated to concrete use cases. With its fine balance between theory and practice, “Topological Data Analysis for Scientific Visualization” constitutes an appealing introduction to the increasingly important topic of topological data analysis for lecturers, students and researchers.

This book presents the development and application of some topological methods in the analysis of data coming from 3D dynamical systems (or related objects). The aim is to...
emphasize the scope and limitations of the methods, what they provide and what they do not provide. Braid theory, the topology of surface homeomorphisms, data analysis and the reconstruction of phase-space dynamics are thoroughly addressed.

Topological Methods in Data Analysis and Visualization III Theory, Algorithms, and Applications

Topological Methods in Data Analysis and Visualization III Theory, Algorithms, and Applications

Complementarity theory is a new domain in applied mathematics and is concerned with the study of complementarity problems. These problems represent a wide class of mathematical models related to optimization, game theory, economic engineering, mechanics, fluid mechanics, stochastic optimal control etc. The book is dedicated to the study of nonlinear complementarity problems by topological methods. Audience: Mathematicians, engineers, economists, specialists working in operations research and anybody interested in applied mathematics or in mathematical modeling.

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This collection of peer-reviewed workshop papers provides comprehensive coverage of cutting-edge research into topological approaches to data analysis and visualization. It encompasses the full range of new algorithms and insights, including fast homology computation, comparative analysis of simplification techniques, and key applications in materials and medical science. The book also addresses core research challenges such as the representation of large and complex datasets, and integrating numerical methods with robust combinatorial algorithms. In keeping with the focus of the TopoInVis 2017 Workshop, the contributions reflect the latest advances in finding experimental solutions to open problems in the sector. They provide an essential snapshot of state-of-the-art research, helping researchers to keep abreast of the latest developments and providing a basis for future work. Gathering papers by some of the world’s leading experts on topological techniques, the book represents a valuable contribution to a field of growing importance, with applications in disciplines ranging from engineering to medicine.

This book presents 13 peer-reviewed papers as written results from the 2005 workshop "Topology-Based Methods in Visualization" that was initiated to enable additional stimulation in this field. It contains a survey of the state-of-the-art, as well original work by leading experts that has not been published before, spanning both theory and applications. It captures key concepts and novel ideas and serves as a basis for future work. Gathering papers by some of the world’s leading experts in topological techniques, the book represents a valuable contribution to a field of growing importance.

The first monograph to treat topological, group-theoretic, and geometric problems of ideal hydrodynamics and magnetohydrodynamics from a unified point of view. It describes the necessary preliminary notions both in hydrodynamics and pure mathematics with numerous examples and figures. The book is accessible to graduates as well as pure and applied mathematicians working in hydrodynamics, Lie groups, dynamical systems, and differential geometry.

This collection of peer-reviewed conference papers provides comprehensive coverage of cutting-edge research in topological approaches to data analysis and visualization. It encompasses the full range of new algorithms and insights, including fast homology computation, comparative analysis of simplification techniques, and key applications in materials and medical science. The volume also features material on core research challenges such as the representation of large and complex datasets and integrating numerical methods with robust combinatorial algorithms. Reflecting the focus of the TopoInVis 2013 conference, the contributions evince the progress currently being made on finding experimental solutions to open problems in the sector. They provide an inclusive snapshot of state-of-the-art research that enables researchers to keep abreast of the latest developments and provides a foundation for future progress. With papers by some of the world’s leading experts in topological techniques, this volume is a major contribution to the literature in a field of growing importance with applications in disciplines that range from engineering to medicine.

Topology-based methods are of increasing importance in the analysis and visualization of datasets from a wide variety of scientific domains such as biology, physics, engineering, and medicine. Current challenges of topology-based techniques include the management of time-dependent data, the representation of large and complex datasets, the characterization of noise and uncertainty, the effective integration of numerical methods with robust combinatorial algorithms, etc. . The editors have brought together the most prominent and best recognized researchers in the field of topology-based data analysis and visualization for a joint discussion and scientific exchange of the latest results in the field. This book contains the best 20 peer-reviewed papers resulting from the discussions and presentations at the third workshop on "Topological Methods in Data Analysis and Visualization", held 2009 in Snowbird, Utah, US. The 2009 "TopoInVis" workshop follows the two successful workshops in 2005 (Slovakia) and 2007 (Germany).

What is the shape of data? How do we describe flows? Can we count by integrating? How do we plan with uncertainty? What is the most compact representation? These questions, while unrelated, become similar when recast into a computational setting. Our input is a set of finite, discrete, noisy samples that describes an abstract space. Our goal is to compute qualitative features of the unknown space. It turns out that topology is sufficiently tolerant to provide us with robust tools. This volume is based on lectures delivered at the 2011 AMS Short Course on Computational Topology, held January 4-5, 2011 in New Orleans, Louisiana. The aim of the book is to provide a broad introduction to recent techniques from applied and computational topology. Afta Zomorodian focuses on topological data analysis via efficient construction of combinatorial structures and recent theories of persistence. Marian Mrozek analyzes asymptotic behavior of dynamical systems via efficient computation of cubical homology. Justin Curry, Robert Ghrist, and Michael Robinson present Euler Calculus, an integral calculus based on the Euler characteristic, and apply it to sensor and network data aggregation. Michael Erdmann explores the relationship of topology, planning, and probability with the strategy complex. Jeff Erickson surveys algorithms and hardness results for topological optimization problems. The DARPA Topological Data Analysis program has supported the development of topological methods for analyzing large sets of points in metric spaces [1-5]. The goal of this project is to develop similar methods for data sets on which the natural structure is not a metric, but rather a partial order. These methods are being developed for application to Boolean data, i.e., sets of bit strings, and to geometrical data, e.g., points in Lorentzian manifolds.

The main purpose of the present volume is to give a survey of some of the most significant achievements obtained by topological methods in non-linear analysis during the last three decades. It is intended, at least partly, as a continuation of Topological Nonlinear Analysis: Degree, Singularity and Variations, published in 1995. The survey articles presented are concerned with three main streams of research, that
is topological degree, singularity theory and variational methods. They reflect the personal taste of the authors, all of them well known and distinguished specialists. A common feature of these articles is to start with a historical introduction and conclude with recent results, giving a dynamic picture of the state of the art on these topics. Let us mention the fact that most of the materials in this book were pre-sented by the authors at the "Second Topological Analysis Workshop on Degree, Singularity and Variations: Developments of the Last 25 Years," held in June 1995 at Villa Tuscolana, Frascati, near Rome.

Michele Matzeu Alfonso Vignoli Editors Topological Nonlinear Analysis II Degree, Singularity and Variations Classical Solutions for a Perturbed N-Body System Gianfausto Dell' Antonio O. Introduction In this review I shall consider the perturbed N-body system, i.e., a system composed of N point bodies of masses m1, ..., mN, described in cartesian co ordinates by the system of equations (0.1) where f) V'k,m == -\Omega^{'m} = 1, 2, 3.

When scientists analyze datasets in a search for underlying phenomena, patterns or causal factors, their first step is often an automatic or semi-automatic search for structures in the data. Of these feature-extraction methods, topological ones stand out due to their solid mathematical foundation. Topologically defined structures—as found in scalar, vector and tensor fields—have proven their merit in a wide range of scientific domains, and scientists have found them to be revealing in subjects such as physics, engineering, and medicine. Full of state-of-the-art research and contemporary hot topics in the subject, this volume is a selection of peer-reviewed papers originally presented at the fourth Workshop on Topology-Based Methods in Data Analysis and Visualization, TopoInVis 2011, held in Zurich, Switzerland. The workshop brought together many of the leading lights in the field for a mixture of formal presentations and discussion. One topic currently generating a great deal of interest, and explored in several chapters here, is the search for topological structures in time-dependent flows, and their relationship with Lagrangian coherent structures. Contributors also focus on discrete topologies of scalar and vector fields, and on persistence-based simplification, among other issues of note. The new research results included in this volume relate to all three key areas in data analysis—theory, algorithms and applications.


Biology has entered the age of Big Data. The technical revolution has transformed the field, and extracting meaningful information from large biological data sets is now a central methodological challenge. Algebraic topology is a well-established branch of pure mathematics that studies qualitative descriptors of the shape of geometric objects. It aims to reduce questions to a comparison of algebraic invariants, such as numbers, which are typically easier to solve. Topological data analysis is a rapidly-developing subfield that leverages the tools of algebraic topology to provide robust multiscale analysis of data sets. This book introduces the central ideas and techniques of topological data analysis and its specific applications to biology, including the evolution of viruses, bacteria and humans, genomics of cancer and single cell characterization of developmental processes. Bridging two disciplines, the book is for researchers and graduate students in genomics and evolutionary biology alongside mathematicians interested in applied topology.

This book presents contributions on topics ranging from novel applications of topological analysis for particular problems, through studies of the effectiveness of modern topological methods, algorithmic improvements on existing methods, and parallel computation of topological structures, all the way to mathematical topologies not previously applied to data analysis. Topological methods are broadly recognized as valuable tools for analyzing the ever-increasing flood of data generated by simulation or acquisition. This is particularly the case in scientific visualization, where the data sets have long since surpassed the ability of the human mind to absorb every single byte of data. The biannual TopoInVis workshop has supported researchers in this area for a decade, and continues to serve as a vital forum for the presentation and discussion of novel results in applications in the area, creating a platform to disseminate knowledge about such implementations throughout and beyond the community. The present volume, resulting from the 2015 TopoInVis workshop held in Annweiler, Germany, will appeal to researchers in the fields of scientific visualization and mathematics, domain scientists with an interest in advanced visualization methods, and developers of visualization software systems.

This book describes current problems in data science and Big Data. Key topics are data classification, Graph Cut, the Laplacian Matrix, Google Page Rank, efficient algorithms, hardness of problems, different types of big data, geometric data structures, topological data processing, and various learning methods. For unsolved problems such as incomplete data relation and reconstruction, the book includes possible solutions and both statistical and computational methods for data analysis. Initial chapters focus on exploring the properties of incomplete data sets and partial-connectedness among data points or data sets. Discussions also cover the completion problem of Netflix matrix; machine learning method on massive data sets; image segmentation and video search. This book introduces software tools for data science and Big Data such MapReduce, Hadoop, and Spark. This book contains three parts. The first part explores the fundamental tools of data science. It includes basic graph theoretical methods, statistical and AI methods for massive data sets. In second part, chapters focus on the procedural treatment of data science problems including machine learning methods, mathematical image and video processing, topological data analysis, and statistical methods. The final section provides case studies on special topics in variational learning, manifold learning, business and financial data rec overy, geometric search, and computing models. Mathematical Problems in Data Science is a valuable resource for researchers and professionals working in data science, information systems and networks. Advanced-level students studying computer science, electrical engineering and mathematics will also find the content helpful.
An introduction to geometric and topological methods to analyze large scale biological data; includes statistics and genomic applications. This book provides a comprehensive overview of the authors' pioneering contributions to nonlinear set-valued analysis by topological methods. The coverage includes fixed point theory, degree theory, the KKM principle, variational inequality theory, the Nash equilibrium point in mathematical economics, the Pareto optimum in optimization, and applications to best approximation theory, partial equations and boundary value problems. Self-contained and unified in presentation, the book considers the existence of equilibrium points of abstract economics in topological vector spaces from the viewpoint of Ky Fan minimax inequalities. It also provides the latest developments in KKM theory and degree theory for nonlinear set-valued mappings. Topological tools in Nonlinear Analysis had a tremendous development during the last few decades. The three main streams of research in this field, Topological Degree, Singularity Theory and Variational Methods, have lately become impetuous rivers of scientific investigation. The process is still going on and the achievements in this area are spectacular. A most promising and rapidly developing field of research is the study of the role that symmetries play in nonlinear problems. Symmetries appear in a quite natural way in many problems in physics and in differential or symplectic geometry, such as closed orbits for autonomous Hamiltonian systems, configurations of symmetric elastic plates under pressure, Hopf Bifurcation, Taylor vortices, convective motions of fluids, oscillations of chemical reactions, etc. Some of these problems have been tackled recently by different techniques using equivariant versions of Degree, Singularity and Variations. The main purpose of the present volume is to give a survey of some of the most significant achievements obtained by topological methods in Nonlinear Analysis during the last two-three decades. The survey articles presented here reflect the personal taste and points of view of the authors (all of them well-known and distinguished specialists in their own fields) on the subject matter. A common feature of these papers is that of starting with an historical introductory background of the different disciplines under consideration and climbing up to the heights of the most recent results. This timely text introduces topological data analysis from scratch, with detailed case studies. This book constitutes the thoroughly refereed proceedings of the 17th International Conference on Discrete Geometry for Computer Imagery, DGCI 2013, held in Seville, Spain, in March 2013. The 34 revised full papers presented were carefully selected from 56 submissions and focus on geometric transforms, discrete and combinatorial tools for image segmentation and analysis, discrete and combinatorial topology, discrete shape representation, recognition and analysis, models for discrete geometry, morphological analysis and discrete tomography. This book gathers the proceedings of the 2018 Abel Symposium, which was held in Geiranger, Norway, on June 4-8, 2018. The symposium offered an overview of the emerging field of "Topological Data Analysis". This volume presents papers on various research directions, notably including applications in neuroscience, materials science, cancer biology, and immune response. Providing an essential snapshot of the status quo, it represents a valuable asset for practitioners and those considering entering the field.