Abstracts

Eli Appleboim

Department of Electrical Engineering, Technion

The Bochner-Weizenböck Identity and Anomaly Detection in Medical Imaging

The Bochner-Weizenböck formula is a fundamental identity in Riemannian Geometry. It connects some of the essential operators in this field such as the Hodge Laplacian' the connection Laplacian and the Ricci curvature into one relation that gives a unified viewpoint. In this talk we will review this fundmental identity and one of its applications in the area of medical image analysis. This application is based on a discrete version of the Bochner-Weizenböck identity that was first introduced by Robin Formann. Its adaptation to Image Processing we present here represents joint work with E. Saucan and Y. Y. Zeevi.

David Blanc

Department of Mathematics, Haifa University

The topology of linkages

Linkages – arrays of bars connected by flexible joints – have been studied mathematically since the 19thcentury, and there has been a renewed interest in the subject in recent years. In particular, the set of all possible embeddings of such a linkage \Gamma in a fixed ambient space (e.g., the plane) has an obvious topology as the ***configuration space*** C(\Gamma), and usually has a smooth structure, too. The study of C(\Gamma) using tools from algebraic and differential topology may yield useful information about the mechanics of the linkage.

Gershon Elber
Computer Science Department, Technion

Volumetric Representations: the Geometric Modeling of the Next Generation

The needs of modern (additive) manufacturing (AM) technologies can be satisfied no longer by boundary representations (B-reps), as AM requires the representation and manipulation of interior fields and materials as well. Further, while the need for a tight coupling between design and analysis has been recognized as crucial almost since geometric modeling (GM) has been conceived, contemporary GM systems only offer a loose link between the two, if at all.

For about half a century, (trimmed) Non Uniform Rational B-spline (NURBs) surfaces has been the B-rep of choice for virtually all the GM industry. Fundamentally, B-rep GM has evolved little during this period. In this talk, we seek to examine an extended volumetric representation (V-rep) that successfully confronts the existing and anticipated design, analysis, and manufacturing foreseen challenges. We extend all fundamental B-rep GM operations, such as primitive and surface constructors and Boolean operations, to trimmed trivariate V-reps. This enables the much needed tight link to (Isogeometric) analysis on one hand and the full support of (heterogeneous and anisotropic) additive manufacturing on the other.

Examples and other applications of V-rep GM, including AM and lattice-and micro-structure synthesis and heterogeneous materials will also be demonstrated.

This work is in collaboration with many others, including Ben Ezair, Fady Massarwi, Boris van Sosin, Jinesh Machchhar, Annalisa Buffa, Giancarlo Sangalli, Pablo Antolin, and Massimiliano Martinelli.

David Fajman
Faculty of Physics, University of Vienna

On the evolution of geometries under the Einstein flow

Considering the Einstein equations as an initial value problem they take the form of a geometric flow that governs the evolution of a Riemannian metric and its time derivative on a given topological manifold. Evolving initial data on different types of topologies towards future and past generates a variety of solutions modelling universes with big bang singularities as well as ever expanding complete ends. We give an overview on selected models, their stability properties and methods to control the evolution of perturbations, as well as variations of the system with matter models coupled to the Einstein equations.

Arielle Leitner

Department of Mathematics, Weizmann Institute

Generalized Cusps on Convex Projective Manifolds

Abstract: Convex projective manifolds are a generalization of hyperbolic manifolds. They are more flexible, and some occur as deformations of hyperbolic manifolds. Generalized cusps occur naturally as ends of properly convex projective manifolds. We classify generalized cusps, discuss their geometry, and ways they can deform. Joint work with Sam Ballas and Daryl Cooper.

Nati Linial
Einstein Institute of Mathematics, Hebrew University

What do we know about the large-scale metric of graphs?

Ronald Lok Ming Lui
Chinese University of Hong Kong

Parametrizing flat-foldable surfaces with incomplete data

We propose a novel way of computing surface folding maps via solving PDEs. This framework is a generalisation to the existing quasiconformal methods but allows manipulation of the geometry of folding. Moreover, the crucial quantity that characterizes the geometry occurs as the coefficient of the equation, namely the Beltrami coefficient. This allows us to solve an inverse problem of parametrizing the folded surface when only partial data and the folding geometry are given. This is a joint work with Syl Qiu.

Manor Mendel
Computer Science Division, The Open University of Israel

Nonpositive curvature is not coarsely universal

We prove that not every metric space embeds coarsely into an Alexandrov space of nonpositive curvature. This answers a question of Gromov (1993) and is in contrast to the fact that any metric space embeds coarsely into an Alexandrov space of nonnegative curvature, as shown by Andoni, Naor and Neiman (2015). We establish this statement by proving that a metric space which is q-barycentric for some $q\in[1,\infty)$ has metric cotype q with sharp scaling parameter. Our proof utilizes nonlinear (metric space-valued) martingale inequalities and yields sharp bounds even for some classical Banach spaces.

Areejit Samal
The Institute of Mathematical Sciences (IMSc), Chennai, India

Geometry-inspired methods for analysis of complex networks

In this talk, I will present our work towards the development of geometry-inspired measures for the characterization of real-world complex networks. In this direction, we have introduced a discretization of the classical Ricci curvature proposed by R. Forman to the domain of complex networks. Forman-Ricci curvature is a concept inspired from Riemannian and polyhedral geometry, and this measure has several advantages for the analysis of large-scale networks. Firstly, most traditional graph-theoretic measures such as degree and clustering coefficient are vertex-specific, and in contrast, Forman-Ricci curvature is a measure for edges in networks. Secondly, the mathematical formula of the Forman-Ricci curvature elegantly allows for the analysis of weighted and unweighted graphs. Thirdly, we have also extended the definition of Forman-Ricci curvature to the realm of directed graphs. Fourthly, an important distinguishing feature of the Forman-Ricci curvature, in contrast to the other well-known discretization, namely, Ollivier-Ricci curvature, is its simplicity and suitability from a computational perspective for analysis of very large networks. In this talk, I will present results from our systematic evaluation of Forman-Ricci curvature in several model and real-world networks. Towards the end of my talk, I will also present our new method to explore persistent homology in unweighted networks by leveraging on Discrete Morse theory.

Jake Solomon

Einstein Institute of Mathematics, Hebrew University

Singular Lagrangian intersections and the non-linear Cauchy-Riemann equation

A classical result of Lojasiewicz says that a bounded gradient flow trajectory of a real analytic function converges to a unique limit. I will discuss an analogous result for maps from a Riemann surface into a symplectic manifold that satisfy the non-linear Cauchy-Riemann equation with real analytic Lagrangian boundary conditions. The proof relies on an isoperimetric inequality that controls the singularities of real analytic Lagrangian intersections.

The Floer cohomology of a pair of Lagrangian submanifolds is defined using solutions of the non-linear Cauchy-Riemann equation, and depends in general on the global geometry of the ambient symplectic manifold. However, as a consequence of our result and Gromov's compactness theorem, we see that in certain situations, the Floer cohomology of a pair of Lagrangian submanifolds is a local invariant. This fits nicely with conjectures relating Floer cohomology and algebraic invariants of singular Lagrangian intersections arising from deformation quantization and perverse sheaves.
No background in symplectic geometry will be assumed. This talk is based on joint work with M. Verbitsky.

Gilbert Weinstein

Physics Department, Ariel University

Plumbing constructions and the domain of outer communication for 5-dimensional black holes

The topology of the domain of outer communication for 5-dimensional stationary bi-axisymmetric black holes is classified in terms of disc bundles over the 2-sphere and plumbing constructions. In particular we find an algorithmic bijective correspondence between the plumbing of disc bundles and the rod structure formalism for such spacetimes. Furthermore, we describe a canonical fill-in for the black hole region and cap for the asymptotic region. The resulting compactified domain of outer communication is then shown to be homeomorphic to S^4, a connected sum of $S^2 \times S^2$'s, or a connected sum of complex projective planes $\mathbb{CP}^2$. Combined with recent existence results, it is shown that all such topological types are realized by vacuum solutions. In addition, our methods treat all possible types of asymptotic ends, including spacetimes which are asymptotically flat, asymptotically Kaluza-Klein, or asymptotically locally Euclidean.

Gershon Wolansky
Mathematics Department, Technion

On Kantorovich (Wasserstein) metrics on probability measures, asymptotic distance, teleportation and optimal networks

I will review the definition of Kantorovich metric on the set of probability measures and discuss the asymptotic distance on the tangent space of this set. I will show that a notion of "teleportation" emerges naturally whenever the scale of the asymptotic distance is changed. If time permit I'll also show some connection with optimal networks and irrigation.