Titles and Abstracts

Thursday

Alvaro Torras Casas (Cardiff University)
Input-Distributive Persistent Homology

Persistent Homology has been developed as an important tool of Topological Data Analysis, with numerous applications in science and engineering. However, for very large data sets this tool can be very expensive to compute, both in terms of computational time and hard-disk memory. We will present a new distributive algorithm which takes part directly on the input data. This has some theoretical difficulties since we need to work within the category of persistence modules. In particular, we will see a solution to the extension problem for the Persistent Mayer-Vietoris spectral sequence. At the end we speculate that this approach might give us more information than ordinary Persistent Homology.

Alessio Cipriani (University of Liverpool)
Perverse Sheaves, Finite Dimensional Algebras and Quivers

In this talk I will introduce the category of perverse sheaves on a topologically stratified space X and give some examples. Then, I will show that when X has finitely many strata, each with finite fundamental group, such category is equivalent to a category of modules over a finite dimensional algebra and to representations of a quiver with relations. Finally, I will explain how to find the (quadratic part of) relations inductively.

Mario Fuentes Rumí (University of Malaga)
The equivariant K- and KO-theory of certain classifying spaces via an equivariant Atiyah-Hirzebruch spectral sequence

We compute the K- and KO-theory for the classifying G-spaces EG for proper actions of certain infinite discrete groups G via a special version of the equivariant Atiyah-Hirzebruch spectral sequence. In particular, a general formula is given for amalgamated product of finite cyclic groups and some infinite Coxeter groups.

Constanze Roitzheim (University of Kent)
Homotopy theory of bicomplexes

Model categories provide a way of talking about homotopy theory in an algebraic setting. We show how to construct model structures on bicomplexes and twisted complexes and explain their relevance in stable homotopy theory.

Sungkyung Kang (University of Oxford)
Connected Heegaard Floer homology of covering involutions

Involutive Heegaard Floer homology of 3-manifolds, defined by Hendricks, is known to give some new obstructions to 3-manifolds from being homology cobordant. Applying their technique to the deck transformation action of branched cyclic covers of S^3 along a knot, we get a set of new concordance invariants. In this talk, we give a way to calculate our invariants for knots satisfying some conditions, and use it to compute them for torus knots and Pretzel knots. This gives some new linear independence results on the knot concordance group. This is a joint work with Antonio Alfieri and Andras Stipsicz.

Nima Rasekh (Max Planck Institute for Mathematics)
An Axiomatic Approach to Algebraic Topology

An elementary higher topos is a higher category that is defined using only elementary conditions, yet behaves similar to the category of spaces. The goal of this talk is to illustrate this connection by proving classical results from algebraic topology in this abstract setting. Concretely, we will use the fact that it satisfies descent, which a kind of a local-to-global condition, to construct natural number objects. This allows us to use inductive arguments. Using induction, we will then construct truncations and show that we can also prove the Blakers-Massey theorem.

Megan Palser (University of Southampton)
Discrete Hodge Theory for Ranking Problems

In an abstract sense, cohomology may be thought of as a measure of the extent to which local properties of a space may be extended to global properties. It is natural then to use cohomology in data analysis where we wish to examine whether a local characterisation of the data may be extended to a global property. One example of an application where this is useful is that of a ranking problem, where we wish to determine whether, given a set X of objects, and a subset $E \subseteq X \times X$ of pairwise comparisons of the objects, we can extend this into a global ranking of the objects in X. The application of a discrete version of a Hodge decomposition - usually defined for differential forms on a manifold - to such a question is known as 'Hodgerank'.

In this talk I will overview the methods of Jiang et al in developing a combinatorial version of Hodge theory for ranking problems, and discuss how similar cohomological methods may be used for a more general class of problems which involve extending local properties of data to global ones.

Abigail Linton (University of Southampton)
Massey products in moment-angle complexes

Massey products are higher cohomology operations that are often important to the study of formality of spaces, among other applications. Moment-angle complexes are topological spaces with a natural underlying combinatorial structure that allows us to study combinatorial obstructions to Massey products in the cohomology of moment-angle complexes. I present two systematic constructions of combinatorial operations on simplicial complexes that create non-trivial higher Massey products on classes of any given degree.

Luca Pol (University of Sheffield)
Localizations and adjunctions: The two Principles

Localization is a fundamental tool in algebra, algebraic geometry, and homotopy theory which allows one to focus in on a small part of the category which is of interest, and to reduce global problems to local ones which are often more manageable. In homotopy theory there are two versions of localizations available: the left and right Bousfield localization. In this talk I will discuss how these two different localizations interact with an adjoint pair of functors between stable categories, and provide mild conditions under which the localized adjunction is an equivalence of homotopy categories. I will also discuss several concrete examples where this machinery applies and manifests its usefulness. This is joint work with Jordan Williamson.

Ana Garcia-Pulido (University of Liverpool)
Geometry of periodic structures

Periodic structures arise naturally in many real world problems. In particular, in chemistry they model solid crystalline structures. One challenge is the absence of a good metric in the space of all periodic structures. In this talk, I will give an introduction to periodic structures, some of the existing "metrics" that attempt to compare crystals, and their shortcomings. I will then discuss our progress in finding a good solution to these problems. This work is joint with Vitaliy Kurlin.

Paul Trygsland (NTNU)
Reeb Spaces

As a first step to better understand the homotopical aspects of Morse theory in a more general setting, I will describe a topological category constructed from a space over $\mathbb{R}$. The classifying space of this category is weakly equivalent to the underlying space. I will talk about connections to classical Morse theory. In particular, we can rewrite the classical Reeb graph as a simplicial set. This will suggest how to define higher Reeb spaces, resulting in a series of approximations starting with the Reeb graph.

Friday

Niall Taggart (Queen's University Belfast)
Unitary calculus from a geometric perspective

Unitary calculus is a variant of functor calculus concerned with the study of functors from complex vector spaces to topological spaces. A functor is approximated by a sequence of polynomial approximations which play the role of polynomial functions from the classical Taylor's Theorem. This data is assembled into a Taylor tower, the layers of which are built from spectra and hence have a familiar homotopy theory.

In this talk, I aim to introduce the theory of unitary functor calculus with motivation coming from geometry and with an emphasis on how model categories have aided in the understanding of the calculus.

Aras Asaad (University of Buckingham)
Persistent Homology to Detect Fake Faces

Topological Data Analysis (TDA) is a new mathematical framework to analyse Bigdata. In this talk, we will establish that the TDA tool of Persistent Homology (PH) provides a rich source of information for designing automatic fake face detection algorithms. The PH-based fake (morph) detection method relies on the discriminating power of the pattern of change in the topological features over the entire sequence of the nested shapes constructed from image landmarks. For each image, we construct sequences of simplicial complexes, whose vertices are the selected set of landmarks, for a sequence of distance thresholds and use a variety of homological invariants to discriminate genuine face images from fake faces. The effect of landmark selection from face images will be discussed, where we illustrate different approaches to build PH from a single face image. We shall demonstrate that many PH-based schemes singularly achieve significant detection rates when tested on 2 large digital datasets (as well as their combinations) and a print-scanned dataset.

Igor Sikora (University of Warwick)
Equivariant loop spaces

Loop spaces play a significant role in algebraic topology. They occur in many places - proof of the Freudenthal Theorem, Puppe sequence etc. Infinite loop spaces provide a different approach to stable homotopy theory. Every n-fold loop space comes with a multiplication which is "commutative up to higher homotopies" - which is usually best described in the language of operads. Action of a little n-discs operad provides tools to compute the homology with $\mathbb{F}_p$ coefficients (for p prime). Non-equivariant loop spaces have their equivariant counterpart. The basic results may be translated into the equivariant setting. However, very little is known about the equivariant version of singular homology of such spaces - aka Bredon homology. During the talk I will attempt to describe basic results and computational tools for classic loop spaces, followed by an introduction to the computations of Bredon homology of equivariant loop spaces.

Ran Levi (University of Aberdeen)
Exploration of Structure and Function in the brain by topological methods

The brain is a vast network of neurons, each of which connected to hundreds and sometimes thousands of others in an intricate and highly complex fashion. Each neuron is capable of performing complicated tasks that are expressed in its firing patterns, but all brain functions are achieved by ensembles of neurons operating in a highly coordinated manner that is informed by the structural connectivity among them. The connectivity structure of brain tissue can naturally be described as a directed graph, possibly with extra "decorations" such as weights on its vertices and edges. Similarly the activity of brain can be depicted as dynamic processes on that graph. Indeed, graph theory has been used in theoretical neuroscience for many years. Until recently the means for studying large networks of neurons that closely resemble the actual brain were missing. Hence validation of theoretical results could only be done in small scale. In 2015 the Blue Brain Project published the first digital reconstruction of a section of brain tissue of a juvenile rat consisting to roughly 30K neurons and 8M synaptic connections. Since then several other much larger reconstructions are being developed. These models allow scientists to study neuroscietific phenomena on an unprecedented scale and with complete control over the entire system. In particular, the fully detailed structural and functional data that the reconstruction produces inspired research by mathematical methods that were not used traditionally in neuroscience, such as algebraic topology and combinatorics. This talk is a survey of past and more recent collaboration with the Blue Brain Project. The basic topological concepts and methods will be described and a selection of observations, experiments and results will be discussed.

Ai Guan (Lancaster University)
Introduction to Koszul duality

Koszul duality is a phenomenon appearing in many areas of mathematics. For example, in rational homotopy theory and deformation theory it leads to the duality between Quillen's Lie models and Sullivan's commutative models of topological spaces, and in representation theory it leads to various equivalences such as the BGG correspondence. I will give an introduction to this circle of ideas, and if time permits, describe some recent work in this direction.

Mariam Pirashvilli (University of Southampton)
Geometry and topology of configuration spaces of molecules

We develop a data-driven approach to understanding molecular conformational spaces and energy landscapes. We explore the different commonly used representations of conformational spaces and the metrics defined on them through a variety of algebraic, geometric and topological tools that have been developed for data analysis. These include geometric methods of finding local dimension of manifolds, persistent homology for exploring the topology of the conformation spaces, and discrete Morse theory for analysing the energy landscapes.

Xin Fu (University of Southampton)
Free circle actions on moment-angle complexes

A moment-angle complex is a space with a coordinatewise torus action. The underlying combinatorial data for its quotient is a pair (K, Λ), where K is a finite simplicial complex and Λ is an integral matrix.

In the case of free actions, the quotient space is a homotopy fiber of a certain map for which the associated Eilenberg-Moore spectral sequence collapses at the E_2 term. In this talk, we will focus on free circle actions and construct a chain complex, relying on the combinatorial data, to calculate the cohomology of the quotient.

Samir Shukla (Indian Institute of Technology Bombay)
Spectral bounds for vanishing of cohomology of clique complexes and the neighbourhood complex of a random graph

Let G be a graph on n vertices and let $L(G)$ denote the (unnormalized) Laplacian of G. Let $\lambda_1 \leq \lambda_2 \leq \ldots \leq \lambda_n$ denote the eigenvalues of $L(G)$. The clique complex of a graph G is the simplicial complex whose simplices are all subsets σ of vertices of G which span a complete subgraph of G. In 2005, Aharoni et al. proved the following result which guarantees the vanishing of cohomology of a clique complex, provided the spectral gap of its 1-skeleton is large enough.

"Let X be the clique complex of a graph G. If $\lambda_2(G) > \frac{kn}{k+1}$ then $\tilde{H}^k(X;\mathbb{R}) = 0$."

In this talk, we generalize the above result of Aharoni et al. for a simplicial complex whose k-skeleton is a clique complex and for a simplicial complex which is a subcomplex of a clique complex having the same 1-skeletons. As an application, we decrease by a logarithmic factor, the upper bound for the threshold for vanishing of cohomology of the neighborhood complex of the Erdös-Rényi random graph derived by Kahle (2007).

Azez Kharouf (University of Haifa)
Higher order Toda brackets

Toda brackets are a type of higher homotopy operation. Like Massey products, they are not always defined, and their value is indeterminate. Nevertheless, they play an important role in algebraic topology and related fields: Toda originally constructed them as a tool for computing homotopy groups of spheres. Adams later showed that they can be used to calculate differentials in spectral sequences. After reviewing the construction and properties of the classical Toda bracket, we shall describe a higher order version, there is two ways to do that. We will provide a diagrammatic description for the system we need to define the higher order Toda brackets, then we will use that to give alternative definition using the homotopy cofiber.

Matt Burfitt (University of Southampton)
Instability of Mapper type algorithms

The goal of topological data analysis is to apply tools form algebraic topology to reveal geometric structures hidden within high dimensional data. Mapper is among its most widely and successfully applied tools providing, a framework for the geometric analysis of point cloud data. Given a number of input parameters, the Mapper algorithm constructs a graph, giving rise to a visual representation of the structure of the data. The Mapper graph is a topological representation, where the placement of individual vertices and edges is not important, while geometric features such as loops and flares are revealed.

However, Mapper's method is rather ad hoc, and would therefore benefit from a formal approach governing how to make the necessary choices. In this talk I will present joint work with Francisco Belchì, Jacek Brodzki, and Mahesan Niranjan. We study how sensitive to perturbations of the data the graph returned by the Mapper algorithm is given a particular tuning of parameters and how this depend on the choice of those parameters. Treating Mapper as a clustering generalisation, we develop a notion of instability of Mapper and study how it is affected by the choices. In particular, we obtain concrete reasons for high values of Mapper instability and experimentally demonstrate how Mapper instability can be used to determine good Mapper outputs.