ATMCS8

Applied Topology: Methods, Computation and Science

June 25-29, 2018

IST Austria, Klosterneuburg, Austria

Program & Abstracts

Scientific Organizers:

Prof. Herbert Edelsbrunner and Prof. Uli Wagner

https://ist.ac.at/atmcs8

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Content

1. About IST Austria

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The Institute of Science and Technology Austria (IST Austria) is an international, multidisciplinary research institution dedicated to basic research in the natural, computer and mathematical sciences.

The Institute is located in the city of Klosterneuburg, 18 km from the center of Vienna. As a PhD granting institution, the graduate school at IST Austria educates doctoral students from diverse and international backgrounds with the aim of cultivating world-class research scientists.

IST Austria was established jointly by the federal government of Austria and the provincial government of Lower Austria and inaugurated in 2009. Currently, nearly 600 employees from about 60 countries work at IST Austria. At present, the faculty of the institute consists of 49 professors. Following the implementation of the ambitious development plan, about 90 research groups will be working at IST Austria in a highly modern environment by 2026.

To foster a creative and interdisciplinary scientific atmosphere, separating organizational structures, such as departments, are avoided at IST Austria. The scientists are organized into independent research groups, each headed by a Professor or a tenure-track Assistant Professor. The decision to promote an Assistant Professor to Professor with a permanent contract is based entirely on an evaluation of the scientific achievements of the Assistant Professor by international experts. Research excellence and promise are the exclusive hiring criteria for all scientists at IST Austria - from doctoral students to professors. The Institute chooses which fields of science to enter based solely on the availability of outstanding individuals. It will pursue a direction of research only if it can compete with the best in the world.

2. Program

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Time	Program June 25	Speaker	Room
08:00	Conference Shuttle leaves from Wien Heiligenstadt – Klosterneuburg Weidling – Niedermarkt Klosterneuburg – Pension Alte Mühle	Pick up in front of Heiligenstadt station, Boschstraße	
08:30-09:30	*Registration*		Foyer
09:30	Welcome Address by Thomas Henzinger, President, IST Austria		RLH
09:45-10:45	**Invited talk Inv-01** Integrating topology and geometry into vehicle tracking systems	**Paul Bendich**	RLH
10:45-11:15	*Coffee Break*		Foyer
11:15-12:15	**Invited talk Inv-02** Learning orientations in a topological map: a neuronal model	**Yuri Dabaghian**	RLH
12:15-14:00	*Lunch Break*		Cafeteria
14:00-14:30	**Contributed talk Con-01** Stabilizing auxiliary persistence information	**Alexander Wagner and Peter Bubenik**	RLH
14:30-15:00	**Contributed talk Con-02** Persistence codebooks for topological data analysis	**Matthias Zeppelzauner, Mateusz Juda and Bartosz Zielinski**	RLH
15:00-15:30	**Contributed talk Con-03** Topological data analysis, roughness, and human red blood cells	**Yu-Min Chung, Madalena Costa, Ary Goldberger and Sarah Day**	RLH
15:30-16:00	*Coffee Break*		Foyer
16:00-16:30	**Contributed talk Con-04** Spanners for topological summaries	**Michael Kerber and Arnur Nigmetov**	RLH
16:30-17:00	**Contributed talk Con-05** Persistence landscapes are graded persistence diagrams	**Leo Betthauser, Peter Bubenik, Parker Edwards**	RLH
17:00-20:00	Poster Session		
20:00	Conference Shuttle leaves for Pension Alte Mühle – Niedermarkt Klosterneuburg – Klosterneuburg Weidling – Wien Heiligenstadt		

Time	Program June 26	Speaker	Room
08:00	Conference Shuttle leaves from Wien Heiligenstadt – Klosterneuburg Weidling – Niedermarkt Klosterneuburg – Pension Alte Mühle	Pick up in front of Heiligenstadt station, Boschstraße	
09:00-09:30	*Registration*		Foyer
09:30-10:30	**Invited talk Inv-03** Applications of algebraic topology in combinatorics and geometry	**Imre Barany**	RLH
10:30-11:00	*Coffee Break*		Foyer
11:00-12:00	**Invited talk Inv-04** Real multiparameter persistent homology	**Ezra Miller**	RLH
12:00-14:00	*Lunch Break*		Cafeteria
14:00-14:30	**Contributed talk Con-06** On the NP-hardness of computing stabilized Betti numbers	**Oliver Gäfvert and Wojciech Chachólski**	RLH
14:30-15:00	**Contributed talk Con-07** Stable signatures for dynamic data via persistent homology	**Woojin Kim and Facundo Mémoli**	RLH
15:00-15:30	**Contributed talk Con-08** Persistent homology methods for asymmetric networks	**Samir Chowdhury and Facundo Mémoli**	RLH
15:30-16:00	*Coffee Break*		Foyer
16:00-16:30	**Contributed talk Con-09** Computational topology with Gudhi	**Pawel Dlotko**	RLH
16:30-17:00	**Contributed talk Con-10** Persistent homology and the upper box dimension	**Benjamin Schweinhart**	RLH
17:15	Short walk through the Vienna Woods to the Conference Dinner		
18:00	*Conference Dinner*		Redlinger Hütte
21:00	Conference Shuttle leaves for Pension Alte Mühle – Niedermarkt Klosterneuburg – Klosterneuburg Weidling – Wien Heiligenstadt		

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Time	Program June 27	Speaker	Room
08:00	Conference Shuttle leaves from Wien Heiligenstadt – Klosterneuburg Weidling – Niedermarkt Klosterneuburg – Pension Alte Mühle	Pick up in front of Heiligenstadt station, Boschstraße	
09:00-09:30	*Registration*		Foyer
09:30-10:30	**Invited talk Inv-05** Connected components strike back	**Dmitriy Morzov**	RLH
10:30-11:00	*Coffee Break*		Foyer
11:00-12:00	**Invited talk Inv-06** Multivariate methods in topological data analysis	**Martina Scolamiero**	RLH
12:15	Departure for the excursion to the Wachau		
13:00-15:15	*Lunch Break*		Stockinger-hof
15:15-15:30	Walk to the Dürnstein Abbey		
15:30-16:30	Guided tour of the Dürnstein Abbey		
16:45-17:30	Wine tasting at the Dürnstein Abbey		
17:45	Transfers back to Wien Heiligenstadt/Niedermarkt Klosterneuburg – IST Austria		

Time	Program June 28	Speaker	Room
08:00	Conference Shuttle leaves from Wien Heiligenstadt – Klosterneuburg Weidling – Niedermarkt Klosterneuburg – Pension Alte Mühle	Pick up in front of Heiligenstadt station, Boschstraße	
09:00-09:30	*Registration*		Foyer
09:30-10:30	**Invited talk Inv-07** Random simplicial complexes	**Nati Linial**	RLH
10:30-11:00	*Coffee Break*		Foyer
11:00-12:00	**Invited talk Inv-08** Bialgebras versus 3-manifolds	**Sergei Matveev**	RLH
12:00-14:00	*Lunch Break*		Cafeteria
14:00-14:30	**Contributed talk Con-11** Semantic folding at Cortical.io	**Erik Graf, Cortical.io, Vienna**	RLH
14:30-15:00	**Contributed talk Con-12** Multiparameter persistence via geometric topology	**Peter Bubenik, Michael Catanzaro**	RLH
15:00-15:30	**Contributed talk Con-13** Distributed computability against adversaries via combinatorial topology	**Vikram Saraph and Maurice Herlihy**	RLH
15:30-16:00	*Coffee Break*		Foyer
16:00-16:30	**Contributed talk Con-14** A computional framework for connection matrices	**Shaun Harker, Konstantin Mischaikow, Kelly Spendlove, and Robert Vandervorst**	RLH
16:30-17:00	**Contributed talk Con-15** Computing immersibility	**Fedor Manin, Shmuel Weinberger**	RLH
17:00-20:00	Panel discussion		RLH
20:00	Conference Shuttle leaves for Pension Alte Mühle – Niedermarkt Klosterneuburg – Klosterneuburg Weidling – Wien Heiligenstadt		

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Time	Program June 29	Speaker	Room
08:00	Conference Shuttle leaves from Wien Heiligenstadt – Klosterneuburg Weidling – Niedermarkt Klosterneuburg – Pension Alte Mühle	Pick up in front of Heiligenstadt station, Boschstraße	
09:00-09:30	*Registration*		Foyer
09:30-10:30	**Invited talk Inv-09** Learning topological state of matter and topological state transition	**Francesco Vaccarino**	RLH
10:30-10:40	*Break*		
10:40-11:40	**Invited talk Inv-10** On algorithmic aspects of topological problems	**Lukas Vokrinek**	RLH
11:40	*Lunch (optional)*		Cafeteria
12:15	Conference Shuttle leaves for Pension Alte Mühle – Niedermarkt Klosterneuburg – Klosterneuburg Weidling – Wien Heiligenstadt		

2.1 Oral Presentations

Invited talk Inv-01
Integrating topology and geometry into vehicle-tracking systems

Presenting Author: Paul Bendich (Duke University and Geometric Data Analysis, Inc.)

Abstract:
The target-tracking task is to gather sensor data from the environment and then to partition these data into tracks that are produced by the same target. A key challenge, especially difficult when multiple targets are present, is to take a sensor observation at a given time and associate it with a previously-existing track (or to declare that this is a new object). Many tracking algorithms (in particular the Multiple Hypothesis Tracker, or MHT) formulate the 'connect-the-dots' problem as one of Bayesian inference, with competing multi-track hypotheses receiving scores.

This talk surveys three recent efforts to integrate topological and geometric information into the formula for computing hypothesis scores. The first uses zero-dimensional persistent homology summaries of kinematic information in car tracking, and the second uses persistent homology summaries in state space to form grouping hypotheses for nautical traffic. Finally, a method using self-similarity matrices is employed to make useful cross-modal comparisons in heterogeneous sensor networks. In all three efforts, large improvements in MHT performance are observed.

This work is done with many collaborators and is funded by multiple sources.

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Invited talk Inv-02
Learning orientations in a topological map: a neuronal model

Presenting Author: Yuri Dabaghian (Rice University)

Abstract:
Spatial cognition in mammals is based on an internalized representation of space, which incorporates relational, metric, angular and other types of spatial information. A key component of this representation is a coarse framework of qualitative spatiotemporal relationships: a topological map of the ambient space encoded by the hippocampal network and filled in with more detailed metrical data provided by other brain regions. Specifically, experimental studies have identified several parts of the brain where neuronal spiking explicitly represents the animal's head and body orientation. The resulting orientation map, as well as the hippocampal `cognitive map' are widely studied not only experimentally but also theoretically and computationally. However, it remains unclear how the inputs provided by these networks may synthesize, i.e., how these different types of spatial information may combine into a single coherent spatial framework and how the brain can intrinsically interpret different patterns of spiking activity as locations or directions. We propose a phenomenological model that combines the hippocampal map of locations with orientations and sheds light into how the animal can learn an affine map of the environment.

Invited talk Inv-03
Applications of algebraic topology in combinatorics and geometry

Presenting Author: Imre Barany (Hungarian Academy of Sciences and University College of London)

Abstract:
I will survey some applications, old and more recent, of algebraic topology in combinatorics and geometry. Examples are Kneser's conjecture (which is now Lovasz's theorem), and the topological Tverberg theorem, and critical points on Alexandrov surfaces.

Invited talk Inv-04
Real multiparameter persistent homology

Presenting Author: Ezra Miller (Duke University)

Abstract:
Persistent homology with multiple continuous parameters presents fundamental challenges different from those arising with one real or multiple discrete parameters. Existing algebraic theories apply either for discrete parameters or for one continuous parameter. In part, the difficulty arises because the relevant modules are wildly infinitely generated. This talk explains how and why real multiparameter persistence should nonetheless be practical for data science applications. The key is a finiteness condition that encodes topological tameness -- which occurs in all modules arising from data -- robustly, in equivalent combinatorial and homological algebraic ways. Out of the tameness condition surprisingly falls much of ordinary (that is, noetherian) commutative algebra, crucially including finite minimal primary decomposition and a concept of minimal generator. The geometry and relevance of these algebraic notions will be explained from scratch, assuming no prior experience with commutative algebra, in the context of two genuine motivating applications: summarizing probability distributions and topology of fruit fly wing veins.

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Invited talk Inv-05
Connected components strike back

Presenting Author: Dmitriy Morozov (Lawrence Berkeley National Laboratory)

Abstract:
We will discuss connected components: why they are more interesting that may first appear and why their efficient computation matters.

Invited talk Inv-06
Multivariate methods in topological data analysis

Presenting Author: Martina Scolamiero (EPFL)

Abstract:
In this talk, I will discuss strategies to improve the applicability of two multivariate topological methods: Mapper and multi-parameter persistence. While Mapper is already commonly used for exploratory data analysis, fundamental questions still need to be solved before multi-parameter persistence can enjoy a similar range of applications.

The problem of identifying informative, stable and computable invariants for multi-parameter persistence is much harder than in the single parameter case. In the first part of this talk, I will describe a framework that allows one to compute a new class of stable invariants for multi-parameter persistence. The key element underlying this novel approach is a metric defined by 'noise systems'. This metric allows some features of datasets to be considered as noise, generalizing the classical notion of interleaving distance.

In the second part of the talk, I will discuss some improvements to Mapper of a more practical nature, arising from an ongoing project in psychiatric research. I will describe the results of this collaboration with an emphasis on methods for validating observations guided by the Mapper graph.

Invited talk Inv-07
Random simplical complexes

Presenting Author: Nati Linial (Hebrew University of Jerusalem)

Abstract:
Nearly 60 years ago, Erdoes and Renyi have begun a systematic study of the so-called G(n,p) random graphs. These have become a key object in all of modern combinatorics and have found numerous applications in other areas of mathematics as well as in computer science, information theory, and more. Perhaps the most important discovery is that combinatorial parameters tend to change abruptly around some “critical” value. Thus around p=log n/n, a random Erdos-Renyi graph changes abruptly from being almost sure disconnected to almost surely connected. Also around p=1/n, a phase transition occurs where a “giant component” emerges and the graph almost surely ceases to be a forest. About 15 years ago, Roy Meshulam and I have started to systematically develop a high-dimensional analog of G(n,p) graphs, namely we investigate random simplicial complexes. In this talk, I will describe some of what we presently know and do not know in this fascinating area.

My collaborators in these investigations are R. Meshulam, T. Luczak, L. Aronshtam, and Y. Peled.

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Invited talk Inv-08
Bialgebras versus 3-manifolds

Presenting Author: Sergei Matveev (Chelyabinsk State University and IMM of RAS)

Abstract:
Several years ago Maxim Kontsevich discovered an interesting connection between operations on bialgebras and 3-manifolds with boundary patterns. He formulated the following conjecture: two operations on bialgebras are equivalent if and only if the corresponding 3-manifolds are homeomorphic (taking into account their boundary patterns.) In my talk, I will describe methods and results of computer verification of this conjecture.

Invited talk Inv-09
Learning topological state of matter and topological phase transition

Presenting Author: Francesco Vaccarino (Politecnico di Torino - ISI Foundation)

Abstract:
Modern topology has been deeply entangled with the study of dynamical and complex systems since its very beginning in the seminal work “Analysis Situ” by Henri Poincaré. The recent rising of Topological Data Analysis and Computational Topology enabled also by the increasing availability of low-cost computational power and the data deluge has made possible to tackle some relevant questions concerning chaotic systems, topological state of matter and phase transition detection and analysis. In this talk, we will present an overview of these themes with a particular focus on phase transitions analysis and topological state of matter by means of suitable blends of computational topology, topological data analysis and machine learning techniques.

Invited talk Inv-10
On algorithmic aspects of topological problems

Presenting Author: Lukas Vokrinek (Charles University, Prague)

Abstract:
I will discuss some classical problems of algebraic topology in relation to their computational status, e.g. the computability of homotopy groups (each computable in polynomial time). Both computability and undecidability results will be covered. The results are due to a group of people including Cadek, Filakovsky, Krcal, Matousek, Sergeraert, Wagner and the speaker. I will also briefly mention a work in progress that concerns an extension to the equivariant setup.

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Contributed talk Con-01
Stabilizing auxiliary persistence information

Authors: Alexander Wagner and Peter Bubenik

Abstract:
The persistence diagram is a stable, algebraic summary of the connectivity of spatial data. The points in the persistence diagram can be represented in the input space, but these representations are notoriously unstable and, as equivalence classes of cycles, hard to visualize. The goal of this work is to produce stable, spatial representations of the persistence diagram on the input data to extend the utility of persistent homology to include visualization for domain experts.

Contributed talk Con-02
Persistence codebooks for topological data analysis

Authors: Matthias Zeppelzauner, Mateusz Juda and Bartosz Zielinski

Abstract:
We extend bag of words (BoW) encodings to persistent homology to cope with the inherent sparsity of persistence diagrams. The representation is obtained by assigning points of the persistence diagram to the precomputed codebook. The proposed approach generates powerful discriminative representations and results in a universally applicable fixed-sized feature vector of low dimension. Furthermore, it can be computed efficiently.

Contributed talk Con-03
Topological data analysis, roughness, and human red blood cells

Authors: Yu-Min Chung, Madalena Costa, Ary Goldberger and Sarah Day

Abstract:
Human red blood cells (RBCs) exhibit spontaneous vibratory motions, referred to as flickering. Previous work using measurements of cell roughness as well as detrended fluctuation analysis and multiscale entropy methods has shown that the short-term flickering motions of RBCs exhibit complex structure and dynamics over multiple spatial and time scales. In addition, these properties (both roughness and temporal complexity) have been shown to degrade with age or disease such that older or diseased cells show significantly less roughness and temporal complexity than newly-formed and healthy cells. However, analyzing time series of spatial patterns is a challenging problem. One difficulty is to quantify spatial patterns. In this work, we study spatial patterns of RBCs using persistent homology. We aim to measure topological features of flickering depicted in the phase contrast microscopy images. We explore the information in persistence diagrams, and find that short lifespan generators, which are commonly considered to be noise, also reveal useful information. In particular, the distribution of generators in persistence diagrams plays an essential role in classifying the cells by functional age.

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Contributed talk Con-04
Spanners for topological summaries

Authors: Michael Kerber and Arnur Nigmetov

Abstract:
Given n persistence diagrams, can we obtain a close approximation of the induced metric space without computing all pairwise distances? We address this question by a spanner construction in the space of persistence diagrams. For that, we adopt the practically efficient cover tree construction to the case of approximate distance computation and construct a well-separated pair decomposition out of the cover tree. Because the space of persistence diagrams is of high doubling dimension, our approach does not yield worst-case guarantees, even under quite favorable assumptions on the input. However, we show that in practice, the number of distance computations drops signicantly for clustered data. Our results and methodology also carry over to the case of Reeb graphs.

Contributed talk Con-05

Persistence landscapes are graded persistence diagrams

Authors: Leo Betthauser, Peter Bubenik, Parker Edwards

Abstract:
In a nutshell, the standard persistence diagram of a persistence module is constructed in two steps: first computing the ranks of the maps from M_i to M_j, and second `differentiating' these ranks via inclusion-exclusion. We introduce the strictly richer graded persistence diagram, which is obtained by differentiating graded ranks. We show that the graded persistence diagram corresponds to the module's persistence landscape, which have been studied before. The correspondence preserves grading information. Furthermore, it places critical points on individual persistence landscape functions in correspondence with points on the graph of the graded persistence diagram while preserving information about those points' criticality.

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Contributed talk Con-06

On the NP-hardness of computing stabilized Betti numbers

Authors: Oliver Gäfvert and Wojciech Chachólski

Abstract:
We show how classical invariants in algebraic topology, such as the Betti numbers, can be adapted to work in a data-analysis setting. This is achieved by what we call hierarchical stabilization. This procedure finds the multiparameter persistence module with minimum value of the invariant in an "-ball of the topology induced by the interleaving distance. For a multiparameter persistence module, the Betti numbers are a set of integers dened as the ranks of the elements of a minimal presentation of the module. They give information about the generators of the module and the complexity of their relations. This invariant is however not stable under perturbation of the underlying dataset. That is, a small perturbation of the data set can result in a completely dierent invariant. However, using hierarchical stabilization we can stabilize it. Moreover, we show in that computing this stabilization is as hard as a rank minimization problem, which is in general NP-hard. For certain cases however, it can be eciently approximated. This is the case for multiparameter clustering, where the persistence module takes values in Sets. This transforms the rank minimization problem to a set covering problem, for which there are tractable approximation algorithms.

Contributed talk Con-07
Stable signatures for dynamic data via persistent homology

Authors: Woojin Kim and Facundo Mémoli

Abstract:
The so called Single Linkage Hierarchical Clustering method produces dendrograms from finite metric spaces in a stable manner: namely, if the input static datasets are close in the Gromov-Hausdorf sense, then the output dendrograms will also be close. This result is further generalized for higher dimensional homological features. In this work we study to what extent one can export similar results to the case of dynamic datasets.

Contributed talk Con-08
Persistent homology methods for asymmetric networks

Authors: Samir Chowdhury and Facundo Mémoli

Abstract:
We provide a collection of stable persistent homology methods on asymmetric structures. This includes generalizations of standard simplicial constructions on metric spaces, as well as non-simplicial constructions that do not have an appropriate analogue in the metric setting. Our constructions are motivated by theoretical results on a family of directed cycle networks that model a directed analogue of the circle.

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Contributed talk Con-09
Computational topology with Gudhi

Author: Pawel Dlotko

Abstract:
Computational geometry and topology are expanding beyond frames of classical mathematics, and as a tool they are used in various branches of science, engineering and most importantly data science. A collection of methods and procedures commonly referred to as topological data analysis (TDA) is already used in medicine, drug discovery, material science, computational engineering, data analysis and many more. That spectacular interest call for providing the state of the art, well documented and tested and most importantly regularly maintained software solutions with a good user support.

Contributed talk Con-10
Persistent homology and the upper box dimension

Author: Benjamin Schweinhart

Abstract:
We prove the rst results relating persistent homology (PH) to a classically dened fractal dimension. Several previous studies have demonstrated an empirical relationship between PH and fractal dimension; our results are the rst rigorous analogue of those comparisons. Specically, we dene a family of PH-dimensions for a metric space, and exhibit hypotheses under which they are comparable to the upper box dimension. In particular, the dimensions coincide for subsets of R2 whose upper box dimension exceeds 1:5: This work also raises interesting questions in extremal combinatorics and geometry.

Contributed talk Con-11
Semantic folding at Cortical.io

Presenting Author: Erik Graf, Cortical.io, Vienna

Abstract:
Cortical.io provides natural language understanding (NLU) solutions to multiple Fortune 100 businesses so they can precisely search their enterprise databases through natural language queries, automate classification of big text data, and extract key information from voluminous quantities of complex documents.

At the core of our business solutions is an unsupervised learning technique called Semantic Folding. Semantic Folding enables learning of individual semantic representation of words and the relations between words by processing utterances of human language in textual form. The system autonomously digests text and projects the learnt semantic meaning into a sparse distributed space that can be interpreted as a graph.
Specifically, we are interested to see if it is possible to identify if syntactic and domain specific regularities of natural language can be characterized by the means of topological analysis.

Contributed talk Con-12
Multiparameter persistence via geometric topology

Authors: Peter Bubenik and Michael Catanzaro

Abstract:
One of the most useful features of persistent homology is the classication of indecomposable persistence modules as interval modules. There is no similar classication of indecomposable modules for multiparameter persistence because the associated representation theory is wild. In this talk, we will define a geometrically motivated model for multiparameter persistent homology using one parameter families of smooth functions on a compact manifold. We will describe the decomposition into indecomposables in geometric terms.

Contributed talk Con-13
Distributed computability against adversaries via combinatorial topology

Authors: Vikram Saraph and Maurice Herlihy

Abstract:
A distributed task is a coordination problem solved by a collection of sequential automata, or processes. Processes begin with private input, communicate via a protocol by reading and writing a shared memory, and return outputs. They are asynchronous and may fail. In previous work, Gafni and Borowsky proved that wait-free shared memory protocols are modeled by a chromatic variant of the barycentric subdivision. This result, together with the simplicial approximation theorem, were instrumental in proving the asynchronous computability theorem, which provides topological criteria for task solvability. In this work, we study a more general model of fault tolerance, in which an adversary controls the failure of certain subsets of processes. By using shellability, connectivity, and transversality arguments, we construct a corresponding protocol complex. Our work yields a theorem for classifying task solvability under this adversary.

Contributed talk Con-14
A computional framework for connection matrices

Authors: Shaun Harker, Konstantin Mischaikow, Kelly Spendlove, and Robert Vandervorst

Abstract:
Algebraic topology and dynamical systems are intimately related: the algebra may constrain or force the existence of certain dynamics. Morse homology is the prototypical theory grounded in this observation. Conley theory is a far-reaching topological generalization of Morse theory and a great deal of effort over the last few decades has established a computational version of the Conley theory. The computational Conley theory is a blend of combinatorics, order theory and algebraic topology and has proven effective in tackling problems within dynamical systems. Within the Conley theory the connection matrix is the mathematical object which transforms the approach into a truly homological theory; it is the Conley-theoretic generalization of the Morse boundary operator. We'll discuss how the connection matrix can be computed efficiently with discrete Morse theoretic techniques.

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Contributed talk Con-15
Computing immersibility

Authors: Fedor Manin and Shmuel Weinberger

Abstract:
Understanding whether the embeddability of manifolds and simplicial complexes in R^n or other manifolds is computationally decidable is an important problem which is open in a large number of cases. Embedding theory is often approached via immersion theory, so whether immersibility is computable may shed some light on this question. We show that for both smooth and PL embeddings, immersion theory does not seem to complicate the computation of embeddability. In particular, in the PL category and in odd codimension, immersibility of manifolds in R^n is decidable. Smooth immersibility in even codimension is undecidable but a stronger condition which always holds for embeddable manifolds is decidable.

2.2 Poster Overview

Poster Nr.	Presenting Author	Poster Title
P-01	Guinti, Chacholski, Landi	Decomposition of filtered chain complexes
P-02	Jimenez, Medrano, Soriano-Trigueros	Topological data analysis for activity recognition
P-03	Gaudreau, Boden, Chrisman	Computing the slice genus and signature of virtual knots
P-04	Obayashi	Volume optimal cycles for persistent homology
P-05	Barthel, Dlotko, Hess, Lee, Moosavi, Smit	Computational screening of the nanoporous materials genome using TDA
P-06	Mike, Perea	Inductive learning on multiscale nerve complexes
P-07	Kusano	Persistence weighted Gaussian kernel for probability distributions on the space of persistence diagrams
P-08	Elkin, Kurlin	A fast recognition of branched shapes of micelles in colloids
P-09	Chowdhury, Dai, Memoli	The importance of forgetting: limiting memory improves recovery of topological characteristics from neural data
P-10	Bubenik, Vergili	Topological spaces of persistence modules
P-11	Kalyanaraman, Kamruzzaman, Krishnamoorty	Interesting paths in the mapper
P-12	Belton, Fasy, Millman, Tomlinson, Wencek	Analyzing musical composition with TDA
P-13	Turaga, Mohammed	Unknot recognition through quantier elimination

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Poster Nr.	Presenting Author	Poster Title
P-14	Chacholski	What is persistence?
P-15	Fugacci, Kerber	Topology-aware terrain simplication
P-16	Salaiz, Ansorge, Shao, Kunoth	Computational topology in the understanding of atmospheric turbulence
P-17	Buchet, Kerber	Approximating k-fold filtrations with weighted Delaunay triangulations
P-18	Anai, Chazal, Glisse, Inakoshi, Tinarrage, Umeda	A weighted filtration for persistent homology with noisy data and data with anomalous observations
P-19	Virk	Persistence of geodesic spaces
P-20	Juda, Mrozek, Dey, Kapela, Kubica, Lipinski	Persistent homology of Morse decompositions in combinatorial dynamics
P-21	Milicevic, Bubenik	Persistence modules as graded modules and their homological algebra
P-22	Takeuchi	The persistent homolog of a sampled map: from a viewpoint of quiver represenations
P-23	Sudo, Ahara	CubicalRipser: a calculator of the persistent homology of cubical complexes
P-24	Cerri, Ethier, Frosini	New advances in comparing 2D persistence diagrams via the coherent matching distance
P-25	Carlsson, Carlsson, Vejdemo-Johansson	Fibres of failure: using Mapper to find failure modes in predictive processes
P-26	Corbet, Fugacci, Kerber, Landi, Wang	A kernel for multi-parameter persistence
P-27	Corbet, Kerber	The representation theorem of persistence revisited and generalized
P-28	Palma, Boys, Scolamiero, Hess	A Mapper based approach for predictive analysis

3. General Information

3.1 Conference dinner and excursion

Tuesday, June 26
The conference dinner will take place at Redlinger Hütte, which is a nice 20-minute walk through the woods from IST Austria. Please let us know should you have difficulties with walking and we will arrange for a taxi transfer.

Wednesday, June 27
Participants are welcome to take part in the conference excursion to the Wachau, which is a picturesque valley formed by the Danube River. It is also listed in the UNESCO List of World Heritage Sites. The buses for the excursion will depart at approximately 12:15. Lunch will take place at the Stockingerhof, which will be followed by a walking tour of the Dürnstein Abbey and wine tasting. The transfers returning to Vienna and Klosterneuburg will depart from Dürnstein at approximately 17:45.

3.2 Conference Location: Raiffeisen Lecture Hall (RLH, Building 02)

Institute of Science and Technology Austria (IST Austria)
Am Campus 1, 3400 Klosterneuburg, Phone: +43 2243 9000

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3.3 Public Transportation to IST Austria

IST Shuttle (Bus #142)

IST Austria provides a shuttle bus for everybody traveling from Wien Heiligenstadt to the campus (and return) to expand the public bus service. The IST Austria Shuttle Bus connects the underground network (U4 Heiligenstadt) and IST Austria with only one stop at Klosterneuburg Stadtplatz. That leads to a reduction in traveling time compared to the public bus. The IST Shuttle takes 22 minutes from Heiligenstadt and runs Monday-Friday. It is, however, very crowded in the mornings and evenings, so please use the provided conference shuttle busses. The public busses take 30 minutes from Heiligenstadt to IST Austria.

IST Shuttle #142

If you decide to take the IST Shuttle Bus, please present the Shuttle Bus invitation. Printed invitations can be picked up at the Registration desk.

Public Bus #239 (please note: please check direction on the schedule, it needs to go to MARIA GUGGING if going to IST Austria!) Tickets can be purchased on the bus.

3.4 Conference Shuttle

Conference Shuttle for everyone staying in Vienna, Hotel Höhenstraße, Hotel Schrannenhof, Hotel Anker, Bürgerhaus Salmeyer, Pension Alte Mühle.

(Wien Heiligenstadt - Klosterneuburg Weidling - Niedermarkt Klosterneuburg - Pension Alte Mühle - IST Austria):

Pick up in front of Heiligenstadt subway station, Boschstraße

Pick up in the mornings:
08:00 Subway station Wien Heiligenstadt
~08:20 Train station Klosterneuburg Weidling (Höhenstraße)
~08:27 Niedermarkt Klosterneuburg (Schrannenhof, Anker, Salmeyer)
~08:32 Public bus stop #239 Mühlengasse (Pension Alte Mühle)

Please note that if you are staying at Hotel Höhenstraße, the conference shuttle bus departing from Wien Heiligenstadt will briefly stop at the train station Klosterneuburg Weidling at approximately 08:20, which is a ten-minute walk from the hotel.

It is advisable that you arrive at your respective pick-up point several minutes earlier to ensure that you do not miss the bus.

Pick up in the evenings:
On Monday & Thursday pick up at IST Austria at 20:00 after the poster session and panel discussion, respectively
On Tuesday pick up at IST Austria at 21:00 after the conference dinner
On Friday pick up at IST Austria at 12:00 after the final Invited Talk

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3.5 Around IST Austria

The area around IST Austria offers a variety of recreational activities. You can walk along the Danube, or hike through the forests of the Buchberg and reward yourself with an unforgettable panoramic view of Klosterneuburg.

- BILLA supermarket, open Mon-Fri 7:15-19:30, Sat 7:15-18:00.
- Museum Gugging www.gugging.org 5-minute walk from IST Austria
- Stift Klosterneuburg (monastery) www.stift-klosterneuburg.at 10-minute walk from Niedermarkt Klosterneuburg
- Happyland - Klosterneuburg's sports centre www.happyland.cc 5-minute walk from Niedermarkt Klosterneuburg
- Redlinger Hütte, www.redlingerhuette.at, a very nice, 20-minute walk through the woods from IST, daily menu
- Der Waldhof (Austrian cuisine), www.der-waldhof.at 10 am - 10 pm, closed on Mondays, 20-minute walk from IST

3.6 Hotels

Hotel Schrannenhof**
3400 Klosterneuburg, Niedermarkt 17-19
+43 2243 32072
info@schrannenhof.at , www.schrannenhof.at

Hotel Restaurant Anker*
3400 Klosterneuburg, Niedermarkt 5
+43 2243 32134
info@hotel-anker.at, www.hotel-anker.at

Bürgerhaus Salmeyer
3400 Klosterneuburg, Stadtplatz 17
+43 2243 32146
info@buergerhaus-salmeyer.at, www.buergerhaus-salmeyer.at

Frühstückspension Alte Mühle*
3400 Klosterneuburg, Mühlengasse 36
+43 2243 37788
info@hotel-altemuehle.at, www.hotel-altemuehle.at

Hotel Höhenstraße*
3400 Klosterneuburg, Kollersteig 6
+43 2243 32191
info@hotel-hoehenstrasse.at, www.hotel-hoehenstrasse.at

Hotel Marienhof*
3413 Unterkirchbach 32
+43 2242/6263
hotel@marienhof-wien.com, www.marienhof-wien.com

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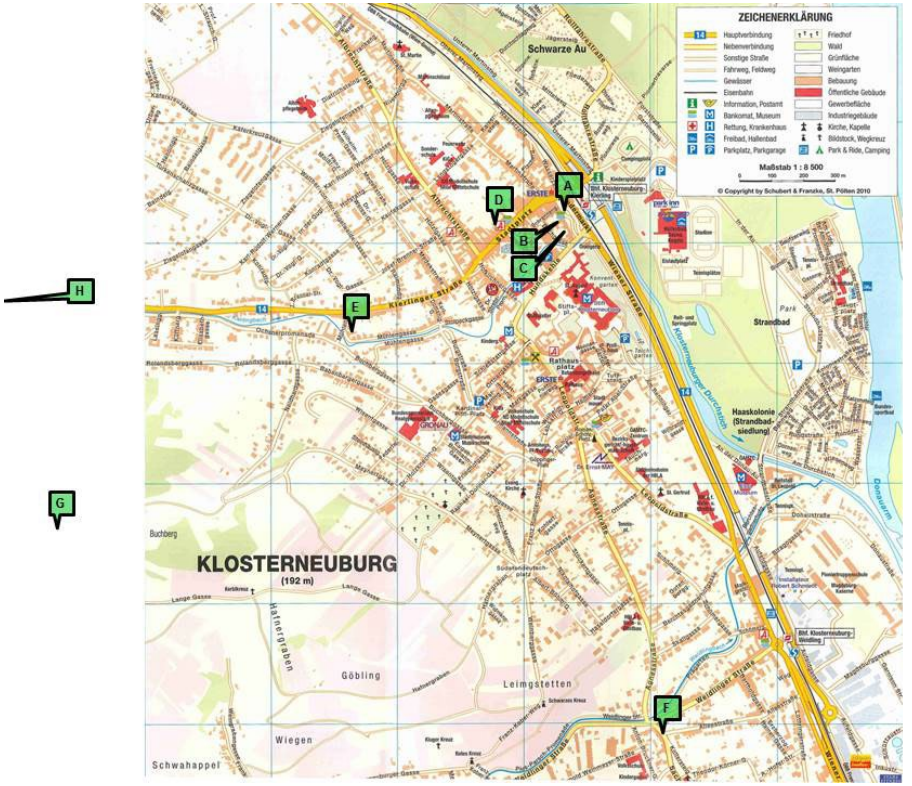
3.7 Map of Klosterneuburg



A Niedermarkt Klosterneuburg (Bus Station)
B Hotel Schrannenhof
C Hotel Restaurant Anker
D Bürgerhaus Salmeyer
E Frühstückspension Alte Mühle
F Hotel Höhenstraße
G Hotel Marienhof
H IST Austria

3.8 Transportation in Vienna

Vienna has efficient public transport consisting of subways (U-Bahn), trams (Straßenbahn) and busses. A single ticket is valid on all means of transport except for the airport (CAT) train. Tickets are bought at the ticket machines located in every subway station and need to be validated by stamping them at the small blue boxes at the entry to the subway platform or inside the trams and busses respectively (subway map is attached). Check www.wienerlinien.at for further information.

For going to the airport, you can either take a cab from IST Austria (approx. 45 minutes-1 hour), or go by public transport (shuttle bus or public bus) to U4 Heiligenstadt, take the U4 line to the stop Landstraße-Wien Mitte, and the direct CAT airport train to the airport (altogether approx. 1½ hours)

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3.9 Taxis

For a cab from IST Austria to Heiligenstadt (U4 stop), Vienna downtown or the airport (best to have cash ready, an ATM is located in the lobby of the Central Building on IST Austria's campus):

- **Taxi Danzinger** (www.taxi-danzinger.at, +43 2243 202 20, +43 676 666 50 70, about 55 EUR to the airport)
- **Taxi Glück** (www.konlechner.at/glueck, +43 2243 361 11, +43 664 224 88 20, about 55 EUR to the airport)
- ask at the IST Austria reception for help

You can take a cab from the airport directly to IST Austria, but be sure to have the full address of the Institute at hand:

IST Austria
Am Campus 1 | 3400 Maria Gugging-Klosterneuburg

Notes