

Dynamics, Topology and Computations DyToComp 2012 24-30 June 2012, Będlewo, Poland

Scientific report

26 sierpnia 2012

1 Summary

Conference Dynamics, Topology and Computations - DyToComp 2012 took place between 24-30 June 2012 in the Mathematical Research and Conference Center in Będlewo, Poland. It was organized by

- Faculty of Mathematics and Computer Science, Jagiellonian University, Kraków
- European Science Foundation,
- Stefan Banach International Mathematical Center, Warszawa,
- The Committee on Mathematics of the Polish Academy of Sciences.

It was the third edition of the DyToComp conference, preceded by the conferences in 2006 and 2009. The present edition was the biggest one, gathering 97 participants, among them many leading specialists in the area of computational and applied topology, computational dynamics and particularly computational topological dynamics. There have been 17 invited, one hour talks and 45 contributed, half-hour talks. Also 6 posters have been presented.

The mathematical conferences in Będlewo are modelled on mathematical conferences in Oberwolfach. The participants live and eat together in the facilities of the conference center. This, besides the talks, provides plenty of time and space for informal talks and discussions.

2 Description of the scientific content of and discussion at the event

The goal of the DyToComp conference series is to promote and develop interactions between topology, dynamics and computations. The scientific interest of the participants was in the areas

of applied and combinatorial topology, dynamical systems, topological dynamics, numerical methods, computer assisted proofs and, particularly, in the intersection of these fields in various combinations. The topics covered included

- topological methods in computer vision
- topological data analysis
- persistent homology
- topology of configuration spaces
- dynamical methods in the topological analysis of configuration spaces of groups
- topological methods in distributed computing
- numerical methods for ordinary and partial differential equations
- rigorous algorithms for dynamical systems,
- computer assisted proofs,
- numerical algorithms for topological invariants,
- KAM theory in classical context and in relation with rigorous numerical methods,
- Conley index based numerical methods.

Massimo Ferri presented the experience of the Vision Mathematics Group in Bologna in applying Persistent Homology (particularly of degree 0, i.e. “Size Functions”) to classification and retrieval of images of natural origin: monograms, leukocytes, face contours, hand-drawn sketches, echocardiograms and melanocytic lesions.

Frédéric Chazal in his talk “Topological data analysis using distance-based functions” provided a short introduction to recent results on how to recover geometric and topological features of an unknown subset of a metric space from the approximating point cloud data by the study of distance functions under various sampling conditions.

Dmitriy Morozov in talk “Algorithms from the Pyramid” presented schemes for computing persistent homology that avoid the reduction of the full boundary matrix of the domain. He used pyramid theorem which relates the decompositions of homology groups of interlevel sets of a real-valued function and also gives recipe for reading the ranks of the homology groups of interlevel sets from a persistence diagram.

Matthew Kahle reported on some preliminary progress on understanding the topology of configuration spaces of hard spheres and results of computational exploration of these spaces.

George Haller described a unified approach to locating key material transport barriers in unsteady flows induced by two-dimensional, non-autonomous dynamical systems. Seeking transport barriers as minimally stretching material lines, one obtains that such barriers must be shadowed by minimal geodesics under the metric induced by the Cauchy-Green strain tensor field associated

with the flow map. Using this approach, hyperbolic barriers (generalized stable and unstable manifolds), elliptic barriers (generalized KAM curves) and parabolic barriers (generalized shear jets) can be found with high precision in temporally aperiodic flows defined over a finite time interval.

Graham Ellis explained how discrete vector fields can be used in the computation of classifying spaces for discrete groups. In particular, he described the computation of classifying spaces and cohomology of some arithmetic groups.

Dmitry Feichtner-Kozlov discussed the application of methods of combinatorial algebraic topology to theoretical distributed computing. He introduced the formal simplicial concepts of a task and a protocol and illustrated it on some of the central tasks of distributed computing. Finally, he presented several theorems which connect topological properties of the associated structures with the computability issues of the related tasks.

The talk of Martin Raussen was devoted to the analysis of the execution of several simultaneous processes sharing common resources by means of the so called directed topology. In particular, Martin described how the topological features of the execution space reflect the behaviour of the processes and how the study of the topology of this infinitely dimensional space may be reduced to the combinatorial case of a so called prosimplicial complex.

Calin Guet gave an insight into recent studies on dynamics of genetic and biochemical interaction networks.

In his talk Amadeu Delshams showed, using geometrical methods, the existence of global instability in the (planar) elliptic restricted three body problem. As the main tool he combined two different scattering maps associated to the degenerate normally hyperbolic manifold of infinity to build trajectories whose angular momentum increases arbitrarily.

Giovanni Federico Gronchi considered the secular evolution of the distance between two Keplerian confocal trajectories in the framework of the averaged restricted 3-body problem. He especially studied the situation when an orbit crossing with the planet occurs and the averaged equations become singular.

Alex Haro presented a novel method to find KAM tori in degenerate (non-twist) cases (with singular Birkhoff normal form). The method provides a natural classification of KAM tori which is based on Singularity Theory. The method also leads to effective algorithms of computation, and we present some preliminary numerical results.

Maciej Capiński presented conditions which ensure existence and smoothness of normally hyperbolic invariant manifolds for maps within a specified domain. The method allows for detection of manifolds in a non-perturbative setting. The required conditions follow from bounds on the first derivative of the map, and are verifiable using rigorous numerics.

Tomas Johnson in his talk described a rigorous numerical method to compute enclosures of the slow manifold of a slow-fast system with one fast and two slow variables. As an application of the method a tangency bifurcation between a slow manifold and the unstable manifold of a saddle-focus equilibrium point is proved.

Denis Gaidashev gave an overview of some recent results for Henon-like area-preserving maps, such as rigid "stable" Cantor sets coexisting with hyperbolic sets, lack of elliptic islands and existence of oscillating orbits. He also put forward a couple of conjectures about period-doubling bifurcations for such maps.

The talk of Arturo Vieiro considered a family of $4D$ symplectic mappings near a doubly resonant elliptic fixed point. He showed that the non-integrability of the normal form is expected because of the generic splitting of the invariant manifolds associated with a normally hyperbolic invariant cylinder.

Ugo Locatelli studied the stability of the planetary problem including Sun, Jupiter, Saturn and Uranus (SJSU, respectively) in the framework of the secular model of order 2 in the masses. Instead of constructing the Birkhoff normal form in the vicinity of the origin, he constructed high order approximation of KAM torus in the vicinity of the “real” orbit and then he evaluated the stability time related to the Birkhoff normal form centered about that KAM torus.

3 Assessment of the results and impact of the event on the future direction of the field

Topology and dynamics have common roots in the seminal work of Henri Poincaré. However, over time these disciplines specialized and spread apart, often forgetting about their common origin. Surprisingly, the ground for a reunification was provided by the computational methods enabled by the development of fast computers of the XXI century. DyToComp conference series builds on this recent reunification. Its outstanding feature is that several teams that normally are spread around the world working in their specific fields are gathered in one place and not only exchange new ideas in their own fields but have the opportunity to learn about the very recent new interactions between topology and dynamics. This stimulates their own research and opens the way to new interactions and common projects. Certainly, this was a particularly strong outcome of the present edition of DyToComp. For the first time the groups representing topology were particularly strong.

Of course, a specific feature of mathematics is that it requires much more time than average to assess the scientific outcomes of a conference. This is because mathematical ideas develop in a slow pace. Nevertheless, it is clear that the conference was very successful: it was enough to listen to the opinions of the participants. In consequence, the dates of the next event in this series have already been fixed for 14-20th June 2015.

4 Final programme of the meeting

25.06, Monday

Lecture Room C	
09:00	DMITRY FEICHTNER-KOZLOV, <i>Topological Methods in Distributed Computing</i>
10:00	FREDERIC CHAZAL, <i>Topological data analysis using distance-based functions</i>
11:00	coffee break
11:30	CALIN GUET, <i>Dynamics of Bio-molecular Networks</i>
12:30	JEAN-PHILIPPE LESSARD, <i>Computation of global smooth manifolds of solutions of PDEs via rigorous multi-parameter continuation</i>
13:00	lunch break
15:00	ZBIGNIEW GALIAS, <i>On rigorous integration of continuous piecewise linear systems</i>
Lecture Room C	Lecture Room A
15:30	KANAME MATSUE, <i>Rigorous numerical verification of local dynamics around equilibria of dynamics in infinite dimensions</i>
16:00	JACEK CYRANKA, <i>Efficient Algorithms for Rigorous Integration of PDEs. Fast Fourier Transforms.</i>
16:30	coffee break
17:00	PIOTR ZGLICZYNSKI, <i>Rigorous numerics for delay equations</i>
17:30	ALEXANDER PROKOPENYA, <i>Equilibrium Solution Stability in the Spatial Circular Restricted Four-Body Problem</i>
18:00	GAETANO ZAMPIERI, <i>Weak instability of Hamiltonian equilibria</i>
	PETER FRANEK, <i>Algorithm for topological degree computation</i>
	LUIS HERNANDEZ-CORBATO, <i>Index of fixed points of orientation-reversing homeomorphisms of \mathbb{R}^3</i>
	HUBERT WAGNER, <i>Computational Topology in Text Mining</i>
	GRZEGORZ JABŁOŃSKI, <i>Persistent homology of maps</i>
	THOMAS WANNER, <i>Randomized Adaptive Topology Validation for Excursion Sets</i>

26.06, Tuesday

	Lecture Room C	
09:00	AMADEU DELSHAMS, <i>Global instability in the elliptic restricted three body problem</i>	
10:00	ALEX HARO, <i>Singularity theory for non-twist KAM tori: A methodology</i>	
11:00	coffee break	
11:30	MARTIN RAUSSEN, <i>Spaces of executions as simplicial complexes</i>	
12:30	LISBETH FAJSTRUP, <i>Periodicity in the Trace Space algorithm.</i>	
13:00	lunch break	
15:00	VALERY GAIKO, <i>Limit cycles of the general Liénard polynomial system</i>	
	Lecture Room C	Lecture Room A
15:30	JAY MIRELES JAMES, <i>Computation of local stable and unstable manifolds by parameterization with rigorous error bounds</i>	FRANK H. LUTZ, <i>Random Methods in Discrete Topology and the Complicatedness of Triangulations</i>
16:00	DANIEL WILCZAK, <i>Uniformly hyperbolic attractors for ODEs - rigorous verification</i>	ABHISHEK RATHOD, <i>A unified framework for efficient algorithms in Computational Topology</i>
16:30	coffee break	
17:00	ALEXANDER WITTIG, <i>Sharp Verified High-Order Enclosures of Invariant Manifolds of ODEs with Parameter Dependence</i>	PIOTR BRENDEL, <i>Homology Computations via Acyclic Subspace</i>
17:30	POSTER SESSION	

27.06, Wednesday

	Lecture Room C	
09:00	DMITRIY MOROZOV, <i>Algorithms from the Pyramid</i>	
10:00	MATTHEW KAHLE, <i>Configuration spaces of hard spheres</i>	
11:00	coffee break	
11:30	GEORGE HALLER, <i>Geodesic Theory of Transport Barriers</i>	
12:30	JAN BOUWE VAN DEN BERG, <i>Forcing chaotic braided solutions in the Swift-Hohenberg equation via topologically validated numerics</i>	
13:00	lunch and excursion	

28.06, Thursday

Lecture Room C	
09:00	MACIEJ CAPIŃSKI, <i>Computer assisted method for existence and higher order smoothness of invariant manifolds</i>
10:00	TOMAS JOHNSON, <i>Rigorous enclosures of slow manifolds</i>
11:00	coffee break
11:30	GRAHAM ELLIS, <i>Discrete vector fields and classifying spaces</i>
12:30	NEZA MRAMOR, <i>Integrability of discrete vector fields</i>
13:00	lunch break
15:00	PIETER COLLINS, <i>Computing the Evolution of Hybrid Systems using Rigorous Function Calculus</i>
Lecture Room C	
Lecture Room A	
15:30	WOJTEK ZAKRZEWSKI, <i>Concept of quasi-integrability and its role in the scattering of (topological) solitons</i>
16:00	IGOR BOGOLUBSKY, <i>On multidimensional solitons and defects</i>
16:30	coffee break
17:00	MARCO SANSOTTERA, <i>On the secular evolution of extrasolar planetary systems</i>
17:30	ANNA GIERZKIEWICZ, <i>First Integrals of the Silent Universe Models</i>
18:00	TOMASZ KAPELA, <i>Rigorous KAM results around arbitrary periodic orbits for Hamiltonian systems</i>
18:30	RODRIGO TREVINO, <i>Flat surfaces, asymptotic homology cycles and ergodic averages</i>

29.06, Friday

Lecture Room C		Lecture Room A	
09:00	DENIS GAIDASHEV, <i>Overview of universality for area-preserving Henon-like maps: results and conjectures</i>	15:30	SERGEI PILYUGIN, <i>Relations between structural stability and shadowing: recent results</i>
10:00	GIOVANNI FEDERICO GRONCHI, <i>The evolution of the orbit distance in the double averaged restricted 3-body problem with crossing singularities</i>	16:00	DMITRII TODOROV, <i>Analogs of Theorems of Maizel And Pliss And Their Application in Shadowing Theory</i>
11:00	coffee break	16:30	coffee break
11:30	MASSIMO FERRI, <i>Persistent Homology and natural images</i>	17:00	THOMAS STEPHENS, <i>Early dynamics in the Cahn-Morral model of phase separation</i>
12:30	CLAUDIA LANDI, <i>The persistence space in multidimensional persistence</i>	17:30	MARCIN KULCZYCKI, <i>On the relationship between the average and the asymptotic average shadowing properties</i>
13:00	lunch break	18:00	IRINA MAKARENKO, <i>Quantitative morphology of the turbulent gas in the Milky Way</i>
15:00	KETTY DE REZENDE, <i>Continuation and Bifurcation Associated to the Dynamical Spectral Sequence</i>		

30.06, Saturday

Lecture Room C	
09:00	ARTURO VIEIRO, <i>Dynamics of 4D symplectic maps near a double resonance.</i>
10:00	coffee break
10:30	UGO LOCATELLI, <i>Long-time stability of the secular part of a planetary problem with more than three bodies</i>
11:30	KRZYSZTOF ZIEMIAŃSKI, <i>Directed paths in d-simplicial complexes</i>
12:00	lunch