

Contract no.: 318493

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Deliverable D5.5

Report on dissemination, collaboration and exploitation activities

Deliverable Nature:	Report (R)
Dissemination Level: (Confidentiality)	Public (PU)
Contractual Delivery Date:	M36
Actual Delivery Date:	M36
Version:	1.0

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Summary

The main objectives of this work package are to make scientific and industrial communities aware of the project and its results; to disseminate project activities and results in related fields or application sectors; and to build a community around the TOPOSYS results and actively maintain a communication channel to its members.

This work package covers exploitation and marketing of the results of the TOPOSYS project in commercial settings. Furthermore, this work package will establish an industrial showcase to illustrate potentials of the TOPOSYS project from an industrial perspective.

Some of the highlight of this year include a second summer school which included participation from TOPDRIM team. There was also a large presence at ACAT events (an ESF network which ended this year) – this provided an effective outlet to disseminating the results produced by the project.

Finally, there a number of results have been accepted and published as well as many more under review.

Dissemination

First for dissemination we describe specific events where TOPOSYS had a significant presence or helped organize.

Dynamics, topology and computations – (Bedlewo, Poland June 15-20) - The conference is devoted to computational aspects of dynamics and topology. TOPOSYS was represented by four out of five partners. A number of relevant results were presented which is listed in the work below.

Summer School on Computational Topology June 22-25, 2015 Faculty of Computer and Information Science Ljubljana – Slovenia - This was the second summer school organized in Ljubljana The main goal of the Summer school was to introduce the basics of new and attractive research fields in Computational Topology and Topological Data Analysis to students and young researchers in Mathematics and Computer Science. The school was aimed mainly at Master or early PhD level students.

The Summer school consisted of a series of lectures by invited lecturers discussing various topics in Computational and Applied Topology. This year there was a greater emphasis on dynamics. Francesco Vaccarino (ISI) who is part of the TOPDRIM project, which is also part of the DYM-CS.

The 4th Annual Minisymposium on Computational Topology - Sheaves and Categories - Symposium of Computational Geometry (Eindhoven, Netherlands) - This minisymposium concentrates on the application of topological techniques to traditional data analysis. This mini-symposium concentrates on how computational geometry and topology fertilize each other, by covering recent advances on the interface of both areas. In this area, TOPOSYS presented on sheaves and categories, specifically introducing the notion of sheaves and related algorithms as well the work on topoidal persistence from Work Package

XXI Oporto Meeting on Geometry, Topology and Physics Foundations of Computational Mathematics (Oporto, Portugal) – This is a meeting, which brings together researchers from mathematicians and physicists. As well as a speaker from IST Austria, results where also presented from JSI.

Discrete, Computational and Algebraic Topology (Copenhagen Denmark) – was co-organized by Herbert Edelsbrunner (IST) and had a presence in terms of invited speakers from the Jozef Stefan Institute and Jagiellonian University. The work on the topoidal foundations of persistence as well as Forman-Morse-Conley theory were presented.

Website

The website is currently up-to-date, with the relevant information.

Community building and Joint Collaborative

Community Building

This year we did not have nay submissions to the conference on complexity science, primarily due to it taking place in the western USA in September. This timing, along with distant location, made attendance impractical for members of the consortium. However, the results of Work Package 3, have begun to be disseminated widely in the community, gaining exposure and interest from outside the consortium. At CAT 2015 at Oxford University, Ieke Moerdijk, one of the pioneers and leading experts in topos theory, has taken in interest in the work. Note that the work of Work Packages 1 and 2 have already been well received by the wider applied topology community (and related fields).

Overall the field has continued to thrive into a community, with complexity science forming an important application area as well as a source of problems for the community.

Joint Collaborative Task

The discussions with ISI have continued and the co-organized summer school in Ljubljana had Francisco Vaccarino present. In addition to TOPDRIM, TOPOSYS has also cooperated with SOPHOCLES. The data produced by SOPHOCLES was not able to be processed effectively unfortunately, due to scalability issues.

Exploitation

The PHAT library has moved to GitHub since Google Code has ceased functioning. It has undergone additional development with the inclusion of arbitrary field coefficients as well as the extension of the algorithms for computing persistent local homology.

The cohomology recurrence program is being incorporated into the analysis of Markov chains models in multivariate time-series data.

Papers

 M. Juda, M. Mrozek CAPD::RedHom v2 - Homology Software Based on Reduction Algorithms, in: Mathematical Software – ICMS 2014, Lecture Notes in Computer Science 8592 (2014), 160--166.

- H. Edelsbrunner, G. Jablonski, M. Mrozek. The Persistent Homology of a Self-map, Foundations of Computational Mathematic, 15(2015), 1213—1244. DOI: 10.1007/s10208-014-9223-y.
- M. Mrozek, R. Srzednicki, F. Weilandt. A topological approach to the algorithmic computation of the Conley index of Poincare operators, SIAM Journal on Applied Dynamical Systems}, 14(2015), 1348—1386.
- K. Mischaikow, M. Mrozek, F. Weilandt. Discretization strategies for computing Conley indices and Morse decompositions of flows, submited.
- P. Brendel, G. Ellis, M. Juda, M. Mrozek Fundamental Group Algorithm for low dimensional tesselated CW complexes preprint 2015, arXiv:1507.03396
- B. Batko, M. Mrozek, Weak index pairs and the Conley index for discrete multivalued dynamical systems, in preparation
- M. Ethier, G. Jablonski, M. Mrozek. Computing the persistence of a self-map with the Kronecker canonical form, in preparation, presented at ACA-ACAT2015
- 2. R.Srzednicki, On computer-assisted proving the existence of periodic and bounded orbits, Annales Mathematicae Silesianae 29 (2015),
- Florian T. Pokorny, Majd Hawasly, Subramanian Ramamoorthy, Topological Trajectory Classification with Filtrations of Simplicial Complexes and Persistent Homology In International Journal of Robotics Research (IJRR), to appear, 2015
- Moshe Cohen, Sunder Ram Krishnan, Random knots using Chebyshev billiard table diagrams,: http://arxiv.org/abs/1505.07681
- G. Naitzat and R.J. Adler, A central limit theorem for the Euler integral of a Gaussian random field http://arxiv.org/abs/1506.08772
- G. Thoppe, D.\ Yogeshwaran and R.J. Adler, On the evolution of topology in dynamic Erdos-Renyi graphs http://arxiv.org/pdf/1503.01983v2
- D. Yogeshwaran, E. Subag and R.J. Adler, Random geometric complexes in the thermodynamic regime http://arxiv.org/pdf/1403.1164v2.
- D. Yogeshwaran and R.J. Adler, On the topology of random processes built over stationary random processes http://arxiv.org/pdf/1211.0061v2
- Antonio Rieser A Topological Approach to Spectral Clustering http://arxiv.org/abs/1506.02633
- R.J. Adler, K. Bartz, S. Kou, and A. Monod, Estimating thresholding levels for random fields via Euler characteristics. http://webee.technion.ac.il/people/adler/LKC-AAS.pdf
- Bartłomiej Błaszczyszyn, D. Yogeshwaran Clustering comparison of point processes with applications to random geometric models http://arxiv.org/abs/1212.5285
- Jan Rupnik, Andrej Muhic, Gregor Leban, Primoz Skraba, Blaz Fortuna, Marko Grobelnik News Across Languages - Cross-Lingual Document Similarity and Event Tracking accepted Journal of Artificial Intelligence Research
- Michael Kerber, Don Sheehy, Primoz Skraba Persistent Homology and Nested Dissection, accepted to SODA 2016
- Carolina Fortuna, Eli De Poorter, Primoz Skraba, Ingrid Moerman Data Driven Wireless Network Design: a Multi-level Modeling Approach, Elsevier Wireless Personal Communications

 Primoz Skraba and Michael Vejdemo-Johannson Topology and Big Data, chapter accepted to Big Data and Optimization

- Primoz Skraba, Bei Wang, Guoning Chen, Paul Rosen. Robustness-based simplification of 2D steady and unsteady vector fields. IEEE transactions on visualization and computer graphics 2015
- Primoz Skraba, Bei Wang, Harsh Bhatia, Guoning Chen, Paul Rosen. Simplifying Critical Points in 3D Vector Fields with Robustness submitted to Eurovis 2016
- Dejan Govc and Primoz Skraba, An Approximate Nerve Theorem, in preparation
- Omer Bobrowski, Matthew Kahle, Primoz Skraba Maximally Persistent Cycles in Random Geometric Complexes, submitted to Annals of Applied Probability
- Ganna Kudryavtseva, Primoz Skraba, The principal bundles over an inverse semigroup, submitted to Semigroup Forum
- P.Frosini, G. Jablonski "Combining persistent homology and invariance groups for shape comparison", preprint, submitted
- H. Edelsbrunner, M. Iglesias-Ham and V. Kurlin. Relaxed disk packing. In Proc. 27 the Canadian Conf. Comput. Geom., 2015
- H. Edelsbrunner and F. Pausinger. Approximation and convergence of the intrinsic volume. Advances in Mathematics, to appear.
- U. Bauer, H. Edelsbrunner, G. Jablonski, M. Mrozek, "Chain maps on Delaunay complexes from discrete and persistence flow", in preparation

Talks

JSI

Primoz Skraba

- Sheaves and Global Section, Functoriality in Geometric Data, HKAUST, Hong Kong
- Sheaves and Global Sections, Applications of Algebraic Topology in Computer Science and Data Analysis (GETCO), Aarhus, Denmark
- Topoidal Persistence, Workshop on Sheaves and Category Theory, Symposium of Computational Geometry, Eindhoven, Netherlands
- Topology and Machine Learning, ISI Institute, Bangalore, India
- An Approximate Nerve Theorem, Dynamics, Topology and Computations. Bedlewo, Poland
- An Approximate Nerve Theorem, Workshop on Applied Topology, IMS Singapore,
 Singapore

Joao Pita Costa

- 2015.07.20 The topos foundation of persistence, Applications of Algebra, Kalamata, Greece.
- 2015.06.22 Persistence on Sheaves over Lifetimes, ACAT Summer School, Ljubljana,
 Slovenia.
- 2015.06.16 The topos foundation of persistence, Conference on Dynamics, Topology and Applications, Bedlewo, Poland.

• 2015.05.18 Topological epidemiological data analysis, ACM Digital Health Conference 2015, Firenze, Italy.

- 2015.03.01 Skew distributive lattices and computational topology, AAA89 General Algebra Conference, Dresden, Germany.
- 2015.02.04 On the topos foundation of persistence, Computational Topology Meeting, Lisbon, Portugal.
- 2014.09.23 Topological analysis of Influenza data, ECCS14, Lucca, Italy
- 2015.09.02 On the stability of the persistence topos, Toposys Final Meeting, Krakow University, Poland.
- 2015.05.27 A topos foundation of persistence. Seminar za Algebro, Fakulteta za Matematika, Ljubljana, Slovenia.
- 2015.05.27 Skew distributive lattices in the topos foundation of persistence, Seminar za Algebro, Fakulteta za Matematika, Ljubljana, Slovenia.
- 2014.11.19 Topological analysis of Influenza data, AI Lab, Inštitut Jozef Štefan, Ljubljana,
 Slovenia.
- 2014.10.08 Variable sets over an algebra of lifetimes: a contribution of lattice theory to the study of computational topology. arxiv:1409.8613. Seminar za Algebro, Fakulteta za Matematika, Ljubljana, Slovenia.

Dejan Govc

• 21st Oporto Meeting on Geometry, Topology and Physics, Lisbon, Portugal, February 4-7, 2015, GOVC, Dejan. New results on the unimodal p-category. Lisbon, 4. 2. 2015.

IST

Herbert Edelsbrunner

- Soft sphere packing. Geometry and Symmetry, dedicated to Karoly Bezdek and Egon Schulte on the occasion of their 60th birthdays, Veszprem, Hungary, June 29, 2015.
- Multiple covers with balls. Intuitive Geometry, Laszlo Fejes Toth Centennial, Budapest, Hungary, June 26, 2015.
- Shape, homology, persistence and stability. AIMR International Symposium, Sendai, Japan, February 17, 2015.
- Metric, homology, persistence. Alan Turing Institute -- Scoping Workshop Topological Data Analysis, Oxford, England, September 11, 2015.
- Multiple covering with balls. Topological Data Analysison Material Science, Sendai, Japan February 20, 2015.
- Distorted cubical complexes and the covering and packing with spheres. Topological Data Analysis on Material Science, Sendai, Japan, February 19, 2015.

Hubert Wagner

- "Practical efficiency of persistent homology computations", FoCM 2014, Montevideo, Uruguay, December 2014.
- "Topological analysis of text data", Holzinger group seminar, Medical University Graz,
 Graz, Austria, February 2015
- "Generalized similarity measure for texts", GETCO 2015, Aalborg, Denmark, April 2015
- "Topological text analysis and generalized similarity measures", DyToComp 2015, Bedlewo, Poland, July 2015
- "Topological Data Analysis with Bregman Divergences", Henzinger Group Seminar, Vienna University, Vienna, Austria July 2015
- "Topological Data Analysis with Bregman Divergences", Geometry Workshop in Seggau
 2015, Seggau, Austria, July 2015
- "Efficient persistent homology computations", ICIAM 2015, Beijing, China, August 2015
- "Topological Data Analysis with Bregman Divergences", Hiraoka Group Seminar, Tohoku University, Sendai, Japan, August 2015
- Topological Data Analysis with Bregman Divergences", Toposys final meeting, Krakow, Poland, September 2015

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KTH

Mikael Vejdemo-Johannson

- 2015-12-08 TEDxKTH, Stockholm, Tieknots
- 2015-09-25 Forskarfredag, Stockholm, Tieknots
- 2015-09-02 Toposys annual, Krakow, Topological Machine Learning
- 2015-06-19 CAT 2015 TDA, Oxford, Topoi
- 2015-06-01 P4 Uppland, Uppsala, Tieknots, Radio show
- 2015-04-16 College of Staten Island, NY, TDA
- 2015-03-12 KTH Scholarship of Teaching and Learning, Stockholm, Didactics
- 2015-01-30 Michigan State University TDA
- 2015-01-21 TU Graz TDA
- 2014-11-06 Mathematics for Digital Science, Brussels, ERC Consultation
- 2014-09-18 AIM, Palo Alto Topoi
- 2014-09-09 Toposys annual, Wien, Topoi

Danica Kragic

- IEEE International Conference on Robotics and Automation 2015 keynote
- IEEE International Conference on Automation Science and Engineering plenary
- IEEE International Conference on Advanced Robotics 2015 plenary

Florian Pokorny

• Jul-15, 2014, Robotics: Science and Systems 2014, Berkeley, US Multiscale Topological Trajectory Classification with Persistent Homology

UJ

Marian Mrozek

- Morse-Forman-Conley theory for combinatorial multivector fields. VII Symposium on Nonlinear Analysis, Toruń, Poland, September 2015.
- Morse-Forman-Conley theory for combinatorial multivector fields.
 6. Forum of Polish Mathematicians, Warsaw, Poland, September 2015.
- Morse-Forman-Conley theory for combinatorial multivector fields.
 Critical Point Theory and Nonlinear Differential Problems, Canazei, Italy, September 2015.
- Morse-Forman-Conley theory for combinatorial multivector fields.
 Geometric and Topological Methods in Computer Science (GETCO 2015), Aalborg University, Aalborg, Denmark, April 2015.
- Persistent Homology of Self-maps. 8th Conference on Foundations f Computational Mathematics, Universidad de la Republica, Montevideo, Uruguay, December 2014.
- Algebraic Morse-Conley Theory for generalized Forman's combinatorial vector fields.
- 8th Conference on Foundations of Computational Mathematics, Universidad de la Republica, Montevideo, Uruguay, December 2014.
- Algebraic Morse-Conley Theory for generalized Forman's combinatorial vector fields.
- Discrete, Computational and Algebraic Topology, University of Copenhagen, Copenhagen, Denmark, November 2014.

Mateusz Juda

- CAPD::RedHom Reduction heuristics for homology algorithms
- International Symposium on Symbolic and Numeric Algorithms for Scientific Computing (SYNASC)
- 5th International Workshop on Computational Topology in Image Context (CTIC);
- Department of Computer Science, West University of Timisoara, Romania; 2014-09-22 -2014-09-225; contributed
- Topological Structures In Gene Expression Data; Genetic Analysis Workshop; Vienna, Austria; 2014-08-24 - 2014-08-27; contributed
- An Introducion to Topological Data Analysis; Recent Advances in OMICS Research and Dissemination Conference of the OMICRON Project; Center for Medical Genomics-

OMICRON Jagiellonian University Medical College, Poland; 2014-10-22 - 2014-10-24; invited

- Seventh de Brún Workshop on Homological Perturbation Theory; NUI Galway, Ireland;
 2014-12-01- 2014-12-015;
- Computing Fundamental Group via Forman's Discrete Morse Theory; Stochastic and Applied Topology Seminar; Technion, Haifa, Israel; 2014-12-09; invited
- Homology of big data algorithms and applications; Advances in interactive Knowledge
 Discovery and Data Mining in complex and big data sets; University of Alberta and Banff
 International Research Station, Banff, Canada; 2015-07-24 2015-07-26; invited

Roman Srzednicki

SNA 2015, Torun (Poland), Sept. 14-18, invited

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Grzegorz Jablonski

- "Persistent homology of eigenvectors and generalized eigenvectors", GETCO 2015, Aalborg, Denmark, 2015.04.07-10
- "Persistence of generalized eigenspaces of self-maps", DYNAMICS, TOPOLOGY AND COMPUTATIONS 2015 (DyToComp), Bedlewo, Poland, 2015.06.15-20,
- "Persistence of generalized eigenspaces of self-maps", ACA 2015 Applications of Computer Algebra, Kalamata, Greece, 2015.07.20-24,

IIT

Robert Adler

- August 2015. Short course on An Introduction to Random Topology, Stochastic Geometry Workshop, Poitiers, France.
- November 2014. Workshop on Discrete, Computational and Algebraic Topology, Copenhagen. Pondering Persistence and Extolling Euler.
- April, 2015. Annual de Rahm Lecture, EPFL, Lausanne, Switzerland. Phase Transitions and Random Topology.
- August 2015. Stochastic Geometry Workshop, Poitiers, France. Topological Phase Transitions
- September 2015. Heilbronn Annual Conference, Bristol, UK. Topological Phase Transitions