

# Michał Lipiński

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## EDUCATION

### Jagiellonian University, Faculty of Mathematics and Computer Science,

- Ph.D. studies in Computer Science Oct 2016 – Nov 2021
  - Thesis: Conley-Morse-Forman theory for generalized combinatorial multivector fields on finite topological spaces
  - Supervisors: Prof. Marian Mrozek, dr Mateusz Juda
- M.S. in Computational Mathematics Oct 2015 – Sep 2017
  - Thesis: Morse decomposition analysis for discrete vector field based on diffusion tensor imaging data
  - Thesis adviser: Ph.D. Marcin Żelawski
  - Keywords: TDA, DTI, Morse Theory, Multivector fields.
  - Average grade: 4.5 / 5.0
  - Final grade: 4.75 / 5.0
  - Graduated with University Honors.
- B.S. in Computational Mathematics Oct 2012 – Jun 2015
  - Thesis: Numerical methods for ordinary differential equations
  - Thesis adviser: Prof. Piotr Zgliczyński

### Jagiellonian University, Faculty of Philosophy,

- M.S. in Cognitive Science Oct 2014 – Sep 2016
  - Thesis: Intelligence and the measures of nerve fibre properties acquired by means of diffusion tensor imaging (DTI): A metaanalysis of research
  - Thesis adviser: Prof. Adam Chuderski
  - Keywords: DTI, white matter, tractography, intelligence.
  - Average grade: 4.48 / 5.0
  - Final grade: 4.74 / 5.0
- B.S. in Cognitive Science Oct 2011 – Jun 2014

### Jagiellonian University, Faculty of Management and Social Communication,

- B.S. in Economics Oct 2009 – Jun 2012
  - Thesis: The process of innovation as a factor of economic development, exemplified by Jagiellonian Centre of Innovation.
  - Thesis adviser: Ph.D. Marek Jarzębiński

### Mikołaj Kopernik 1st General Secondary School in Krosno,

Sep 2006 – Jun 2009

## PUBLICATIONS

- [1] M. Lipiński, D. Mosquera-Lois, and M. Przybylski, "Morse theory for loop-free categories," *arXiv:2107.06202*, 2021.
- [2] B. Zieliński, M. Lipiński, M. Juda, M. Zeppelzauer, and P. Dłotko, "Persistence codebooks for Topological Data Analysis," *Artificial Intelligence Reviews*, 54 (3) pp. 1969–2009, 2021.
- [3] M. Lipiński, J. Kubica, M. Mrozek, and T. Wanner, "Conley-Morse-Forman theory for generalized combinatorial multivector fields on finite topological spaces," *arXiv:1911.12698v2*, 2020. (in review)
- [4] B. Zieliński, M. Lipiński, M. Juda, M. Zeppelzauer, and P. Dłotko, "Persistence Bag-of-Words for Topological Data Analysis," *Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence (IJCAI-19)*, pp. 4489–4495, 2019.
- [5] T. K. Dey, M. Juda, T. Kapela, J. Kubica, M. Lipiński, and M. Mrozek, "Persistent Homology of Morse Decompositions in Combinatorial Dynamics," *SIAM Journal of Applied Dynamical Systems*, vol. 18, no. 1, pp. 510–530, 2019.

## AWARDS:

## GRANTS:

- Executor in the grant **OPUS 18** (35/B/ST1/00874) awarded by National Science Centre in Poland in 2019. Project title: *Combinatorial dynamics in Big Data*. Principal investigator: prof. Marian Mrozek
- Executor in the grant **TANGO 3** (434/080/NCBR/2019) awarded by The National Centre for Research and Development in Poland in 2019. Project title: *Combinatorial dynamics*. Principal investigator: dr Mateusz Juda
- **Principal Investigator** in the pre-doctoral grant **PRELUDIUM 15** (2018/29/N/ST1/00449) awarded by National Science Centre in Poland in 2018. Project title: *Multivalued combinatorial dynamics for a finite topological spaces*.
- Executor in the grant **SONATA 10** (19/D/ST6/01215) awarded by National Science Centre in Poland in 2015. Project title: *Detectors and descriptors of characteristic points based on topological information*. Principal investigator: dr Bartosz Zieliński

## RESEARCH EXPERIENCE

### CURRENT RESEARCH:

#### **The generalized combinatorial multivector fields theory for finite topological spaces**

- Theoretical part:
  - Financed by research grant: NCN Preludium (2018/29/N/ST1/00449). Role: principal investigator
  - One of the main goals of this project is to create a combinatorial counterpart for continuous vector fields. The developed theory is based on the idea of combinatorial vector fields introduced by Robin Forman. We introduce combinatorial analogs of an isolated invariant set, isolating neighborhood, Conley index, and Morse decomposition.
  - With the established generalized version of the theory, we try to state and study the continuation problem of an invariant set in the combinatorial setting.
- Applied part:
  - Financed by research grant: NCBR Tango (434080-TopDyn). Role: executor
  - We implemented an interactive program for computing and visualizing multivector fields.
  - We study the potential of the multivector fields theory as a new data analysis tool, e.g., for the reconstruction of a dynamic from data.

#### **Morse pre-decomposition**

- This project concerns the refinement of the concept of Morse decomposition for dynamical systems that will allow studying the internal structure of Morse sets.

#### **Persistence codebook for topological data analysis.**

- Financed by research grant: NCN Sonata (2015/19/D/ST6/01215); Role: executor
- In this project, we develop a family of flexible and efficient descriptors for the primary topological data analysis tool, that is, for persistence diagrams. The proposed vectorization methods allow to transform topological information into a fixed-length vector; and, thus, to apply it as an input for deep learning algorithms, e.g., for classification purposes.

### PAST PROJECTS:

#### **Cortical thinning in adult cigarette smokers: a large scale structural MRI study**

Principal investigator: Prof. Marcin Szwed, Jagiellonian University Jul 2017 – Aug 2018

- My role: data analyst and programmer, including MRI brain scans processing and statistical analysis.
- About: Investigation of an impact of cigarette smoking on a brain structure, using a large sample of 502 scans we have shown that smoking correlates with reduction of gray matter volume, in particular in superior parietal cortex (attentional areas).

#### **Śródbłonek naczyniowy w chorobach cywilizacyjnych**

Principal investigator: Prof. Stefan Chłopicki, JCET Jun 2014 – Sep 2015

- Advisor: Ph.D. Bartosz Zieliński
- My role: programmer and algorithms designer.
- About: Our subproject involved development and implementation of an algorithm for automatic tracking of an arterial wall and measuring arterial width. In collaboration with angiologists from The University Hospital in Cracow.

SCIENTIFIC  
EVENTS

INVITED TALKS

**Oxford Applied Topology Seminar, on-line**

Given talk: 20 Nov 2020  
*Conley-Morse-Froman theory for generalized combinatorial multivector fields.*

CONFERENCE TALKS

**2nd Symposium on Machine Learning and Dynamical Systems, 2020, on-line**

Given talk: 21–29 Sep 2020  
*Persistence codebooks for topological data analysis.*

**Algebraic Topology Methods, Computation, and Science, 2020, on-line**

Given talk: 20 Aug 2020  
*Conley-Morse-Froman theory for generalized combinatorial multivector fields.*

**Jubilee Congress for the 100th anniversary of the Polish Mathematical Society 2019, Cracow, Poland**

Given talk: 3–7 Sep 2019  
*Combinatorial multivector fields theory for finite topological spaces.*

**Young Topologists Meeting 2019, Lozanna, Switzerland**

Presented poster: 22–26 Jul 2019  
*Combinatorial multivector fields theory for finite topological spaces.*

**Dragon Applied Topology Conference 2018, Swansea, Great Britain**

Given talk: 11–14 Sep 2018  
*Persistent homology of Morse decomposition in combinatorial dynamics.*

**Dynamics, Topology and Computations, DyToComp 2018, Będlewo, Poland**

Given talk: 18–23 Jun 2018  
*Persistent homology of Morse decomposition in combinatorial dynamics.*

**International Conference on Algebra and Related Topics, ICART 2018, Rabat, Morocco**

Given talk: 02–05 Jul 2018  
*Persistent homology of Morse decomposition in combinatorial dynamics.*

**Neuronus, IBRO Neuroscience Forum in Krakow, Poland**

Presented poster: 20–22 Apr 2018  
*Cortical thinning in adult cigarette smokers: a large-scale structural MRI study*

**IX Interdisciplinary Scientific Conference “Tygiel”, Lublin, Poland**

Given talk (in Polish): 18–19 Mar 2017  
*Zastosowania topologicznej analizy danych w neuroobrazowaniu funkcjonalnym.*

SCHOOLS

**Applied Mathematical Modeling with Topological Techniques, ICERM, Providence, Rhode Island, USA**

Participant 5–9 Aug 2018

**Summer school in dynamics, ICTP, Trieste, Italy**

Participant 16–27 Jul 2018

**Winter workshop on dynamics, topology and computations 2018, Będlewo, Poland**

Participant 28 Jun–03 Feb 2018

**Winter workshop: Computational brain connectivity mapping, Juan-les-Pins, France**

Participant 20–24 Nov 2017

**Persistent homology summer school, Rabat, Morocco**

Given talk: 03–07 Jul 2017  
*Analysis of EEG functional brain networks with topological tools*

**Winter workshop on dynamics, topology and computations 2017, Będlewo, Poland**

Participant 12–18 Feb 2017

<b>TEACHING EXPERIENCE</b>	<b>Faculty of Mathematics and Computer Science, Jagiellonian University</b>	
	<ul style="list-style-type: none"> <li>▪ Teaching assistant <span style="float: right;">2018 – Present</span> <ul style="list-style-type: none"> <li>• Conducted courses: introduction to set theory and mathematical logic, linear algebra, topology, computational topology, programming methods.</li> <li>• Awarded with Diamond Chalk for the best tutor of 2021 granted by Faculty’s Student Council.</li> </ul> </li> </ul>	
	<b>Private tutoring in mathematics</b>	
	<ul style="list-style-type: none"> <li>▪ Lessons for high school and university students <span style="float: right;">2012 – 2015</span></li> </ul>	
<b>PROFESSIONAL EXPERIENCE</b>	<b>Ericpol, Cracow, Poland</b>	
	Junior C++ programmer and software designer: <span style="float: right;">Jun 2015 – Sep 2015</span> <ul style="list-style-type: none"> <li>▪ Project: Automatic Upgrade Platform System for automatic software update for embedded devices</li> </ul>	
	<b>E-podróżnik, Cracow, Poland</b>	
	Junior Java programmer and software designer: <span style="float: right;">Aug 2014 – Nov 2014</span> <ul style="list-style-type: none"> <li>▪ Project: ConVis Software for interactive visualization, databases filtering, and presentation of the geographical location of communication networks using OpenStreetMap</li> <li>▪ Project: Peeper An interactive program for monitoring multiple indicators of system load and displaying charts in real-time.</li> </ul>	
<b>STUDENT PROJECTS</b>	<b>Slicer 4D</b>	
	Interactive software for visualization of ”3D slices” of 4D objects constructed with hypercubes (written with C++, OpenGL).	
	<b>Boids simulation,</b>	
	Interactive simple simulator for collective behavior, e.g., bird flocking or fish schools (written with C++, OpenGL).	
<b>LANGUAGES</b>	<ul style="list-style-type: none"> <li>▪ Polish: Native language.</li> <li>▪ English: Fluent (speaking, reading, writing).             <ul style="list-style-type: none"> <li>• Certified by C1+ exam.</li> </ul> </li> </ul>	
<b>SKILLS</b>	<ul style="list-style-type: none"> <li>▪ Programming: C++, C, Java, Python, Octave/Matlab, Mathematica, Git, L<sup>A</sup>T<sub>E</sub>X</li> <li>▪ Software: FSL, FreeSurfer, Inkscape, MS Office</li> </ul>	
<b>INTERESTS</b>	<b>SCIENCE RELATED</b>	
	algebraic topology, complex systems, dynamical systems, emergence, evolution, origins of life, philosophy.	
	<b>OTHER</b>	
	music, singing (my band: Last Universal Common Ancestor, click the name to go to YT), sci-fi, computer games, motorcycle, swimming.	

[CV compiled on 2021-11-10]

[Wyrażam zgodę na przetwarzanie danych osobowych zawartych w niniejszym dokumencie do realizacji procesu rekrutacji zgodnie z ustawą z dnia 10 maja 2018 roku o ochronie danych osobowych (Dz. Ustaw z 2018, poz. 1000) oraz zgodnie z Rozporządzeniem Parlamentu Europejskiego i Rady (UE) 2016/679 z dnia 27 kwietnia 2016 r. w sprawie ochrony osób fizycznych w związku z przetwarzaniem danych osobowych i w sprawie swobodnego przepływu takich danych oraz uchylenia dyrektywy 95/46/WE (RODO).]