Woojin Kim

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Employment / Education

Aug 2020 - July 2023 **Duke University**, NC
William W. Elliott Assistant Research Professor of Mathematics (Mentor: Ezra Miller)

May 2020 **The Ohio State University**, OH Ph.D. in Mathematics
Thesis: The Persistent Topology of Dynamic Data (Advisor: Facundo Mémoli)

Aug 2014 **Seoul National University**, South Korea B.S.in Mathematics Education (with Honors)
Korean National Secondary Teacher Certificate (Grade II) of Math

Research interests

Theory and applications of Topological Data Analysis (TDA), Persistence Theory, Computational Topology, Topology/Algebra/Geometry in Machine Learning, Quiver representations

Publications

Peer-reviewed articles and preprints (Google Scholar)

(* denotes graduate student coauthor. In every publication, author names are listed in alphabetical order.)

12. *The discriminating power of the generalized rank invariant* (with N. Clause* and F. Mémoli), arxiv/2207.11591 (23 pages), **submitted.** 2022

11. *Bigraded Betti numbers and generalized persistence diagrams* (with S. Moore*), arXiv/2111.02551 (26 pages), Last update: July 2022, **submitted.** 2022

10. *Interleaving by parts: Join decompositions of interleavings and join-assemblage of geodesics* (with F. Mémoli, A. Stefanou), arXiv/1912.04366 (43 pages), Last update: July, 2022, **submitted.** 2022

9. *Extracting persistent clusters in dynamic data via Möbius inversion*, (with F. Mémoli), arXiv/1712.04064 (54 pages), Last update: Feb, 2022, **submitted.** 2022

8. *Computing generalized rank invariant for 2-parameter persistence modules via zigzag persistence and its applications* (with T. Dey, F. Mémoli)
Proceedings of the 38th Int. Symp. on Computational Geometry (SOCG), 17 pages, Link
Invited to **Discrete & Computational Geometry**, a special issue dedicated to best papers from SOCG.
arXiv/2111.15058 (21 pages), Last update: March, 2022, **submitted.** 2022

7. Elder-rule-staircodes for augmented metric spaces (with C. Cai*, F. Mémoli, Y. Wang)
SIAM Journal of Applied Algebra and Geometry, 5 (3) pp. 417-454 (38 pages), Journal, arXiv. 2021

6. Generalized persistence diagrams for persistence modules over posets (with F. Mémoli)
Journal of Applied and Computational Topology, 5, pp. 533–581 (48 pages), Journal, arXiv. 2021

5. Spatiotemporal persistent homology for dynamic metric spaces (with F. Mémoli)
Discrete & Computational Geometry, 66, pp.831–875 (44 pages) Journal, arXiv. 2021

4. The Persistent Topology of Dynamic Data
Ph.D. Thesis (244 pages), Link 2020

3. Analysis of dynamic graphs and dynamic metric spaces via zigzag persistence (with F. Mémoli, Z. Smith*)
Proceedings of The Abel Symp. 2018: Topological Data Analysis, pp.371-389 (18 pages), Link 2020

2. Elder-rule-staircodes for augmented metric spaces (with C. Cai*, F. Mémoli, Y. Wang)
Proceedings of the 36th Int. Symp. on Computational Geometry (SOCG) (17 pages), Link 2020

1. Formigrams: Clustering Summaries of Dynamic Data (with F. Mémoli)
Proceedings of the 30th Canadian Conf. on Computational Geometry (CCCG) (9 pages) Link 2018

Quality assessment of conferences (SoCG and CCCG)

SOCG: The flagship conference in Computational Geometry and Topology (ERA rank: A); source Usually 7-10 submissions are invited to *Discrete & Computational Geometry* a year from SOCG. In 2022, there were 174 submissions (of which 64 were accepted for publication in the proceedings). Rank **6** of **177** in subject category *Algorithms & Theory* according to Microsoft Academic's conference field ratings (2014). Average acceptance rate over 2017-2021 is 36%; source

CCCG: Rank **40** of **177** in subject category *Algorithms & Theory*, according to Microsoft Academic's conference field ratings (2014). Average acceptance rate over 2017-2021 is 73%; source

Extended Abstracts

Stable signatures for dynamic metric spaces via persistent homology (with F. Mémoli) in **Statistics for Data with Geometric Structure. Oberwolfach Report, 3**, pp.169-172. Link 2018

Computational software / Expository webpages

(* Graduate students, ** Undergraduate students)

4. Spatiotemporal persistent homology (with N. Clause*) Software (Github) 2020

3. Elder-rule-staircodes (with C. Cai*, F. Memoli, Y. Wang) Software (Github) 2020

2. Classification of collective behaviors via zigzag persistent homology (with Z. Smith** and F. Mémoli)2019
Expository webpage

1. Formigramator (with D. Verano**): Software (a web-based GUI) 2019

Talks

(■: invited, □: contributed, ♣: poster presentations)

■ AMS Southeastern Spring Sectional Meeting (Topological Persistence) March 2023
TBD

■ The Joint Mathematics Meetings 2023 (Applied Topology: Theory and Implementation) January 2023
Persistence diagrams via limit-to-colimit maps and Möbius inversions

■ Applied Topology seminar at University at Albany, SUNY December 2022
Extracting Persistent Clusters in Dynamic Data via Möbius inversion

■ Algebra/Topology seminar at University at Albany, SUNY December 2022
Persistence Diagrams at the Crossroads of Algebra and Combinatorics

■ Computational Persistence Workshop at Purdue University (virtual) November 2022
Computing generalized rank invariant for 2-parameter persistence modules via zigzag persistence

■ International Conference on Advances in Interdisciplinary Statistics and Combinatorics October 2022
Persistence diagrams via limit-to-colimit maps and Möbius inversions

□ ATMCS 10: Algebraic Topology: Methods, Computation, & Science at Oxford University June 2022
Extracting Persistent Clusters in Dynamic Data via Möbius inversion Acceptance rate: 27%

□ SoCG 2022: The 38th International Symposium on Computational Geometry in Berlin June 2022
Computing generalized rank invariant for 2-parameter persistence modules via zigzag persistence
Acceptance rate: 37%

■ The 2022 CMS Summer Meeting at Memorial University in St. Johns, Canada June 2022
Persistence diagrams via limit-to-colimit maps and Möbius inversions

■ Geometry-Topology seminar at Oregon State (virtual) April 2022
Persistence diagrams via limit-to-colimit maps and Möbius inversions

□ Workshop on Algebraic Combinatorics and Category Theory in Topological Data Analysis (virtual)
Extracting Persistent Clusters in Dynamic Data via Möbius inversion March 2022

■ AMS Southeastern Spring Sectional Meeting, U of Virginia March 2022
Canceled due to pandemic.

■ AMS Southeastern Fall Sectional Meeting, U of Alabama (virtual) November 2021
Persistent Cluster Analysis in Dynamic Data via Möbius Inversion

■ Topology and Data seminar, U of Oklahoma (virtual) November 2021
Persistent Cluster Analysis in Dynamic Data via Möbius Inversion

■ Metrics in Multiparameter Persistence at Lorentz Center in Netherland (virtual) July 2021
The Persistent Topology of Dynamic Data

□ Topological Insight in Neuroscience at MSRI, Berkeley (virtual) May 2021
The Persistent Topology of Dynamic Data

□ Topological Data Analysis at IMSI, Chicago (virtual) April 2021
Interleaving by Parts for Persistence In a Poset

■ Topological Data Analysis seminar at Purdue University (virtual) March 2021
The Persistent Topology of Dynamic Data

■ DynamIC seminar at Imperial College London (virtual) March 2021
The Persistent Topology of Dynamic Data

■ Second Symposium on Machine Learning and Dynamical Systems, Fields Institute (virtual). Sept. 2020
Spatiotemporal persistent homology for dynamic metric spaces

■ The Grad-Faculty seminar at Duke Univ (virtual). September 2020
The Persistent Topology of Dynamic Data

□ SoCG 2020: The 36th International Symposium on Computational Geometry (virtual) June 2020
Elder-rule-staircodes for augmented metric spaces
Acceptance rate: 34%

□ ATMCS 9: Algebraic Topology: Methods, Computation, and Science (hosted by AATRN) June 2020
Spatiotemporal persistent homology for dynamic metric spaces

■ The University of Florida Topological Data Analysis workshop January 2020
Generalized persistence diagrams for persistence modules over posets

■ The Joint Mathematics Meetings 2020 in Denver, CO (Special Session on Applied Topology) Jan. 2020
Spatiotemporal persistent homology for dynamic metric spaces

■ Topology seminar at Colorado State October 2019
Generalized persistence diagrams for persistence modules over posets

□ Union College Math Conference (Applied Topology Session) September 2019
Generalized persistence diagrams for persistence modules over posets

■ Applied Topology seminar at University at Albany, SUNY September 2019
Spatiotemporal persistent homology for dynamic metric spaces

■ Topology, Geometry and Data Analysis seminar at Ohio State September 2019
Generalized persistence diagrams for persistence modules over posets

■ Air Force Research Lab in Dayton, Ohio July 2019
Topological data analysis of time-evolving metric data

♣ Midwest Student Conf.: Geometry and Topology meet Data Analysis and Machine Learning June 2019
Persistent homology for dynamic metric spaces

♣ TGDA@OSU: Structure in the micro-world May 2019
Persistent homology for dynamic metric spaces

♣ Conference on Geometric Data Analysis at University of Chicago May 2019
Persistent homology for dynamic metric spaces

□ Great Lake SIAM at University of Michigan April 2019
Multiparameter persistent homology for time-varying metric data

□ Mathematics Graduate Student Association Lecture at Ohio State April 2019
Rank of a diagram and its application in topological data analysis

■ Brown-bag seminar at the Dept of CMSE, Michigan State April 2019
Multiparameter persistent homology for time-varying metric data

■ Bubenik's research group meeting at University of Florida March 2019
Rank invariant and generalized persistence diagrams for zigzag persistence

■ Topology seminar at Florida State March 2019
Persistent homology for time-evolving metric/network data

□ Topology, Geometry, and Applications - Graduate Students Seminar at Ohio State February 2019
Multiparameter persistent homology for time-varying metric data

♣ Workshop on Applied Topology at Kyoto Univ January 2019
Rank invariant for zigzag modules

□ Topology, Geometry, and Applications - Graduate Students Seminar at Ohio State November 2018
Rank for arbitrary diagrams

□ The 30th Canadian Conference on Computational Geometry, University of Manitoba August 2018
Formigrams: Clustering summaries of dynamic data

■ AMS Spring Central Sectional Meeting at Ohio State March 2018
Stable signatures for dynamic metric spaces via zigzag persistent homology

■ Dept. of Mathematics Education, Seoul National University July 2016
Topological and geometric ideas in data analysis

□ More than 30 talks at Ohio State 2015 - 2020

Research and expository talks about topological data analysis, networks, optimal transport, probability, and differential/metric geometry. Links: 1, 2, 3, 4, 5, 6

Awards

Special Graduate Assignments OSU Math department fellowship (exemption from teaching duty) Spring 2018, Spring 2020

Travel Grants for 11 conference attendances: ATMCS–Oxford (2022), CMS–Memorial Univ (2022), U of Florida (2020), JMM-AMS (2020), Brown (2019), U of Chicago (2019), U of Michigan (2019), Kyoto Univ (2019), U of Minnesota (2018), U of Bonn (2018), Carnegie Mellon (2017)

Referee

Algebras and Representation Theory (Springer)

Algorithms - Special Issue on Topological Data Analysis (MDPI)

Computational Geometry: Theory and Applications (Elsevier)

Discrete & Computational Geometry (Springer)

Foundations of Data Science (AIMS)

Journal of Applied and Computational Topology (Springer)

Proceedings of International Symposium on Computational Geometry (2019, 2020, 2021, 2022)
Research in Computational Topology (Springer)
SIAM Journal of Applied Algebra and Geometry

Organizing activities

- Co-organizer of Workshop on Algebraic Combinatorics and Category Theory in Topological Data Analysis (with A. McCleary, A. Patel, F. Mémoli) March 2022
- Chair of the organizing committee: The 1st Midwest Graduate Student Conference: Geometry and Topology meet Data Analysis and Machine Learning (Co-organizers: S. Chowdhury, W. Kim, S. Lim, L.Polanco, K. Singhal, Z. Wan, L. Zhou) June 2019
- Co-organizer of activities in Ezra Miller's group meetings (with E. Miller) Spring 2022
- Organizer of activities in Network Data Analysis group at OSU 2018-2019

Mentoring and Outreach

Research mentoring

- Samantha Moore (a math Ph.D. student at Univ. of North Carolina at Chapel hill) Nov 2020-May 2022
  We coauthored Item 11 in Publications.
- Nate Clause (a math Ph.D. student at Ohio State) 2019-
  We coauthored Item 12 in Publications and Item 4 in Computational Software.
- Dave Verano (an CS undergraduate student at Ohio State) Autumn 2019
  We coauthored Item 1 in Computational Software.

Mentor of Twoples

- Elly Do (Dickinson College), *now: a PhD student at NC State (2022)* Fall 2021
  Project title: Pólya enumeration theorem (Combinatorics)
- Andrew Dias (Southern New Hampshire Univ.), *now: a master's student at Brandeis (2022)* Spring 2021
  Project title: Separation axioms and the Tietze extension theorem (Topology)

Twoples (website) is a mentorship program for undergraduates interested in pursuing a research-based graduate degree in math. Twoples especially aims to provide such mentorship to students from underrepresented groups or non-traditional backgrounds, as well as to students at non-research oriented colleges/universities.

Other mentoring

- Nathanael Ong (a math undergrad at Duke) December 2020-
  Irregular informal meetings since Nathanael had taken my class in Fall 2020.
- Sunhyuk Lim (a math Ph.D. student at Ohio State) October 2020 - January 2021
  Weekly remote meetings
- Ying Yin (a math master's student at Ohio State) 2018-2019
  Weekly meetings (Spring 2018) and Irregular meetings (Fall 2018-Spring 2019)
- Alexander Elchesen (a math master's student at Ohio State) 2016-2017
  Weekly meetings

Graduate Teaching Assistant training TA (selected by TA coordinator in the department)
for all Math graduate students who start teaching at Ohio State Summer 2019

Talks in professional development seminars at Ohio State

- How to prepare a talk, and use of Beamer July 2021
- On the final year in a Math Ph.D. program and job applications January 2021

Thesis Committee

- Joey Li (undergrad at Duke), *Algebraic data structures for decomposing multipersistence modules* 2020

Vlearn faculty member (invited to informal meetings by Duke undergraduate students), Link Fall 2020 -

Teaching

Duke University

- Probability (Math/Stat 230), 2 sections, Solo instructor — Fall 2022
- Probability (Math/Stat 230), 2 sections, Solo instructor — Spring 2022
- Combinatorics (Math 371), Solo instructor — Fall 2021
- Linear Algebra and Differential Equations (Math 216D), 3 sections, Discussion Session TA — Spring 2021
- Multivariable Calculus (Math 212D), 3 sections, Discussion Session TA — Fall 2020

The Ohio State University

- Introduction to Applied Algebraic Topology, Lecturer for 2 weeks — Spring 2019
  A substitute for the original lecturer Tom Needham
- Calculus for Engineers A (Math 1172), 2 sections, Discussion Session TA — Fall 2016
- Calculus 2 (Math 1152), 2 sections, Discussion Session TA — Spring 2016
- Calculus 3 and Topics for Engineers, Tutor — Fall 2014, Spring 2015, Fall 2015
  Tutored 4 hours per week at Math and Stat Learning Center at OSU