

HANBAEK LYU

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EMPLOYMENT

University of Wisconsin - Madison	Assistant Professor	Sep. 2021 -
University of California, Los Angeles	Hedrick Assistant Professor	Jul. 2018 - Jun. 2021

EDUCATION

The Ohio State University	Ph.D in Mathematics (Advised by David Sivakoff) Thesis: <i>Combinatorial and probabilistic aspects of coupled oscillators</i>	Aug. 2013 - Apr. 2018
Seoul National University	B.S. in Mathematics	Mar. 2008 - Feb. 2013

RESEARCH INTEREST

- **Fields of research:** Probability, combinatorics, dynamical systems, optimization, and machine learning
- **General interest:** Emergent properties of spatial processes; convergence of online/distributed algorithms; MCMC sampling; Online learning algorithms and inference

RESEARCH GRANTS

- NSF** [DMS-2206296](#) : *Online Dictionary Learning for Dependent and Multimodal Data Samples: Convergence, Complexity, and Applications. 2022-2025*
Award amount: \$300,000 (Role: Principal Investigator)
- NSF** [DMS-2010035](#): *Combinatorial and probabilistic approaches to oscillator and clock synchronization. 2020-2023*
Award amount: \$146,953 (Role: Principal Investigator)

PUBLICATIONS

(author*=undergraduate student)

Publications

- [1] H. Lyu, F. Memoli, and D. Sivakoff, "Sampling random graph homomorphisms and applications to network data analysis." *Journal of Machine Learning Research*, 24(9):1-79, 2023. ([Journal Preprint](#), [GitHub](#))
- [2] (From REU project) H. Bassi*, R. Yim*, R. Kodukula*, J. Vendrow*, C. Zhu*, H. Lyu, *Learning to predict synchronization of coupled oscillators on randomly generated graphs*. *Scientific Reports* 12, Article number: 15056 ([Journal](#), [GitHub](#)) (2022)
- [3] H. Lyu, C. Strohmeier, and D. Needell, "Online nonnegative tensor factorization and CP-dictionary Learning for Markovian data." *Journal of Machine Learning Research*, 23(148):1-50, 2022 ([Journal](#), [Preprint](#), [GitHub](#))
- [4] M. Junge and H. Lyu, "The phase structure in asymmetric ballistic annihilation" *The Annals of Applied Probability* 32.5 (2022): 3797-3816 ([Journal](#), [Preprint](#))
- [5] H. Lyu and I. Pak, "On the number of contingency tables and the independence heuristic." *Bulletin of the London Mathematical Society* 54 (1), 242-255, 2022 ([Journal](#), [Preprint](#))

- [6] M. Damron, H. Lyu, and D. Sivakoff, "Stretched exponential decay for subcritical parking times on \mathbb{Z}^d ." *Random Structures and Algorithms* 59 (2), 143-154, 2021 ([Journal](#), [Preprint](#))
- [7] H. Lyu, D. Needell, and L. Balzano, "Online matrix factorization for Markovian data and applications to Network Dictionary Learning." *Journal of Machine Learning Research*. 21(251):1-49, 2020 ([Journal](#), [Preprint](#), [GitHub](#))
- [8] C. Strohmeier, H. Lyu, and D. Needell, "Online nonnegative CP tensor factorization for Markovian data" *NeurIPS workshop on Optimization for Machine Learning* 2020. ([Publication](#), [Poster](#))
- [9] H. Lyu, C. Strohmeier, G. Menz, and D. Needell, "Applications of Online Nonnegative Matrix Factorization to Image and Time-Series Data" 2020 Information Theory and Applications Workshop (ITA) ([Publication](#), [Preprint](#))
- [10] L. Levine, H. Lyu, and J. Pike, "Double jump phase transition in a soliton cellular automaton." *International Mathematics Research Notices*, Volume 2022, Issue 1, January 2022, Pages 665-727, ([Journal](#), [Preprint](#))
- [11] H. Lyu, "Chromatic number, cycles, and non-separating cycles." *Graphs and Combinatorics*. 36, 12971310 (2020) ([Journal](#), [Preprint](#))
- [12] S. Dittmer, H. Lyu, and I. Pak, "Phase transition in random contingency tables with non-uniform margins." *Trans. Amer. Math. Soc.* 373 (2020), pp. 8313-8338. ([Journal](#), [Preprint](#))
- [13] A. Kuniba and H. Lyu, "Large deviations and one-sided scaling limit of random multicolor box-ball system" *Journal of Statistical Physics*, 178(1), 38-74 (2019) ([Journal](#), [Preprint](#))
- [14] A. Kuniba, H. Lyu, and M. Okado, "Randomized box-ball systems, limit shape of rigged configurations, and thermodynamic Bethe ansatz" *Nuclear Physics B* (2018), Vol. 937, 240-271. ([Journal](#), [Preprint](#))
- [15] M. Damron, J. Gravner, M. Junge, H. Lyu, and D. Sivakoff, "Parking on transitive unimodular graphs." *Annals of Applied Probability*, Volume 29, Number 4 (2019), 2089-2113 ([Journal](#), [Preprint](#))
- [16] H. Lyu and D. Sivakoff "Persistence of sums of correlated increments and clustering in cellular automata" *Stochastic Processes and Applications* (2018), Vol. 129, Issue 4. ([Journal](#), [Preprint](#))
- [17] E. Foxall and H. Lyu, "Clustering in three and four color cyclic particle systems in one dimension" *Journal of Statistical Physics* (2018), Vol. 171, Issue 3, 470483. ([Journal](#), [Preprint](#))
- [18] H. Lyu, "Global synchronization of pulse-coupled oscillators on trees." *SIAM Journal on Applied Dynamical Systems* (2018), Vol. 17, No. 2. ([Journal](#), [Preprint](#))
- [19] J. Gravner, H. Lyu, and D. Sivakoff, "Limiting behavior of 3-color excitable media on arbitrary graphs." *Annals of Applied Probability*, Vol. 28, Number 6 (2018), 3324-3357. ([Journal](#), [Preprint](#))
- [20] H. Lyu, "Synchronization of finite-state pulse-coupled oscillators.", *Physica D: Nonlinear Phenomena* 303 (2015): 28-38. ([Journal](#), [Preprint](#))

Preprints

- [21] J. Lee, H. Lyu, and W. Yao, "Supervised Dictionary Learning with Auxiliary Covariates" [Preprint](#) (2022)
- [22] A. Alacaoglu and H. Lyu, "Convergence and Complexity of Stochastic Subgradient Methods with Dependent Data for Nonconvex Optimization" [Preprint](#) (2022)
- [23] H. Lyu, "Convergence and complexity of stochastic block majorization-minimization" [Preprint](#) (2022)
- [24] H. Lyu, "Convergence of block coordinate descent with diminishing radius for nonconvex optimization" [Preprint](#) (2020)
- [25] L. Benitez, M. Junge, H. Lyu, M. Redman, L. Reeves, "Three-velocity coalescing ballistic annihilation". [Preprint](#) (2020)
- [26] H. Lyu, Y. Kureh, J. Vendrow*, and M. A. Porter, "Learning low-rank latent mesoscale structures of networks" ([Preprint](#), [GitHub](#), [Python package "ndlearn"](#)) (2020)
- [27] L. Kassab, A. Kryshchenk, H. Lyu, D. Molitor, D. Needell, and E. Rebrova, "On Nonnegative Matrix and Tensor Decompositions for COVID-19 Twitter Dynamics" Submitted. [Preprint](#) (2020)
- [28] T. Johnson, M. Junge, H. Lyu, and D. Sivakoff, "Particle density in diffusion-limited annihilating systems" Submitted. [Preprint](#) (2020)

- [29] H. Lyu, C. Strohmeier, G. Menz, and D. Needell, "COVID-19 Time-series prediction by joint dictionary learning and online NMF" Submitted ([Preprint](#), [GitHub](#)) (2020)
- [30] (From REU project) Y. Guo*, N. Hanoian*, Z. Lin*, N. Liskij*, H. Lyu, D. Needell, J. Qu*, H. Sojico*, Y. Wang*, Z. Xiong*, and Z. Zou*, "Topic-aware Chatbot Using Recurrent Neural Networks and Nonnegative Matrix Factorization." ([Preprint](#), [GitHub](#)) (2019)
- [31] J. Lewis, H. Lyu, P. Pylyavskyy, and A. Sen, "Scaling limit of soliton lengths in a multicolor box-ball system." Submitted. [Preprint](#) (2019)
- [32] H. Lyu and D. Sivakoff "Synchronization of finite-state pulse-coupled oscillators on \mathbb{Z} ." [Preprint](#) (2017)
- [33] H. Lyu, "Phase transition in firefly cellular automata on finite trees." [Preprint](#) (2017)

In preparation

- [34] H. Cai, H. Lyu, D. Needell, and C. Strohmeier, "Robust Online CP Dictionary Learning", In preparation
- [35] S. Ahn, J. Richey, L. Wang, M. Junge, H. Lyu, and D. Sivakoff, "Phase transition in parking process with coalescing cars", In preparation

Unpublished notes

- [36] H. Lyu, "A Note on Graph Characteristics and Hadwiger's Conjecture." [Preprint](#) (2012)
- [37] H. Lyu and P. Jablonski, "Four-Dimensional Discrete-time Lotka-Volterra Models with an Application to Ecology." [Preprint](#) (2012)

REFEREED JOURNALS/CONFERENCES

Mathematical Physics, Analysis and Geometry
 Artificial Intelligence and Statistics
 Journal of Cellular Automata
 Optimization for Machine Learning: OPT 2021
 Combinatorics, Probability, and Computing
 SIAM Journal on Numerical Analysis
 SIAM Journal on Mathematical Analysis
 Journal of American Mathematical Society (quick opinion)
 Communications in Mathematical Physics
 Mathematical Reviews
 ALEA: Latin American Journal of Probability and Mathematical Statistics
 Electronic Journal of Probability
 Linear Algebra and its Applications
 Journal of Statistical Physics
 Nonlinear Dynamics
 Journal of Nonlinear Science
 Automatica
 IEEE Transactions in Cybernetics

INVITED TALKS

"Mesoscale reconstruction of images and networks using tensor decomposition, IPAM, Workshop IV: Multi-Modal Imaging with Deep Learning and Modeling, Nov. 28, 2022 [[slides](#), [YouTube](#)]

"Scaling limit of soliton statistics of a multicolor box-ball system", CUNY Probability Seminar, Nov. 22, 2022

"Learning low-rank mesoscale structure of networks", Columbia Applied Probability Seminar, Nov. 16, 2022

"Scaling limit of soliton statistics of a multicolor box-ball system", CRM Workshop on box-ball systems from integrable systems and probabilistic perspectives, Montreal, Sep 19-23, 2022 [[YouTube](#)]

"Convergence and Complexity of Stochastic Regularized Majorization-Minimization", KIAS, Jun. 13, 2022 [[slides](#)]

"Matrix and Tensor Factorization Models: Applications, Algorithms, and Theory", KRAFTON, Jun. 10, 2022 [[slides](#)]

"Matrix and Tensor Factorization Models: Applications, Algorithms, and Theory", Optimization Seminar, SNU, Jun. 8, 2022

"Introduction to matrix and tensor factorization models and related stochastic nonconvex and constrained optimization algorithms", BIMAGS Seminar, KAIST, Jun. 2, 2022 [[slides](#)]

"Introduction to matrix and tensor factorization models and related stochastic nonconvex and constrained optimization algorithms", BIMAGS Seminar, KAIST, Jun. 2, 2022 [[slides](#)]

"Introduction to matrix and tensor factorization models and related stochastic nonconvex and constrained optimization algorithms", MINDS Seminar, POSTECH, May 31, 2022 [[slides](#)]

"Convergence and Complexity of Stochastic Block Majorization-Minimization", Statistics Seminar, UW-Madison, UCLA, Feb. 23, 2022 [[slides](#)]

"Convergence and Complexity of Block Coordinate Descent with Diminishing Radius and Proximal Regularization", Applied Math and Optimization Seminars, UCLA, Jan. 11, 2022

"Convergence and Complexity of Block Coordinate Descent with Diminishing Radius and Proximal Regularization", IFDS Ideas forum, UW-Madison, Oct. 29, 2021

"Online Dictionary Learning from Dependent Data Samples and Networks", SILO seminar, UW-Madison, Oct. 13, 2021

"Scaling limit of soliton statistics of a multicolor box-ball system", Probability Seminar, UW-Madison, Sep. 16, 2021

"Online Nonnegative Tensor Factorization and CP Decomposition", SIAM Minisymposium on Low Rank Methods in Data Science and Machine Learning, May 21, 2021

"On the number of contingency tables and independent heuristic", AMS Special Session on Probability and Combinatorics, Mar. 21, 2021

"Online matrix factorization for Markovian data", NeurIPS workshop on Optimization for Machine Learning, Dec. 11, 2020

"Online robust matrix factorization for dependent data streams", Applied math and data science seminar, HKUST, Mar. 25, 2020

"Stochastic optimization for dependent data streams and Network Dictionary Learning", UCLA applied mathematics colloquium, Nov. 10, 2020

"Learning parts of networks by motif sampling and online matrix factorization", Information Theory and Applications, SD, Feb 6, 2020

"Large deviations and one-sided scaling limit of randomized box-ball system", AMS Special Session on Random Matrices and Integrable Systems, I., JMM 2020, Jan 18, 2020

"Online matrix factorization for Markovian data", AMS Special Session on Iterative Methods for Large-Scale Data Analysis, JMM 2020, Jan 16, 2020

"Learning parts of networks by motif sampling and online matrix factorization", UCLA Applied Math Colloquium, Jan 8, 2020

"Online matrix factorization for Markovian data and applications to Network Dictionary Learning", Probability seminar, Seoul National University, Nov. 27, 2019

"Sampling random graph homomorphisms and applications to network data analysis", Austin - TAMU Probability and Related Fields, TAMU, Oct. 25, 2019

"Stability inequalities of some probabilistic network observables", TDA seminar, UCLA, Oct. 17, 2019

"Online nonnegative matrix factorization for Markovian data", *Random matrix seminar*, Random matrix seminar, UCLA, Oct. 9, 2019

"Phase transition in random contingency tables with non-uniform margins", Combinatorics Seminar, University of Michigan, Sep. 27, 2019

"Stable network observables via dynamic embedding of motifs", Probability seminar, CUNY, May. 7, 2019

"Phase transition in random contingency table with non-uniform margins", Probability seminar, OSU, Apr. 11, 2019

"Stable network observables and dynamic embedding of motifs into networks", TGDA Seminar, OSU, Apr. 9, 2019

"Phase transition in random contingency table with asymmetric margins" Probability Seminar, USC, Apr. 5, 2019

"Synchronization of firefly cellular automata on various graphs", Applied math seminar, University of Alberta, Mar 25, 2019

"Phase transition in random contingency table with asymmetric margins", Interacting Particle Systems Conference, IPAM, Mar. 9, 2019

"Stable network observables and dynamic embedding of motifs into networks", Probability Seminar, UCSD, Feb. 28, 2019

"Dynamic embedding of motifs into networks", Probability Seminar, UCI, Dec 11, 2018

"Phase transition in box-ball system and its spatial generalization", Integrable systems seminar, Tokyo University, June 19, 2018

"Double jump phase transition in soliton cellular automata", Southeastern Probability Conference, Duke University, May 14-15, 2018

"Double jump phase transition in soliton cellular automata", Probability Seminar, University of California, Los Angeles, April 19, 2018

"Double jump phase transition in soliton cellular automata", Probability Seminar, University of Pennsylvania, Mar 27, 2018

"Double jump phase transition in random soliton cellular automaton", Combinatorics seminar, University of Minnesota, March 2, 2018

"Double jump phase transition in random soliton cellular automaton", Combinatorics seminar, University of Michigan, Jan 26, 2018

"Global synchronization of pulse-coupled oscillators on trees", AMS Contributing papers on Applied Mathematics III, Joint Mathematics Meetings 2018, San Diego

"Limiting behavior of 3-color excitable media on arbitrary graphs", AMS Special Session on Emergent Phenomena in discrete models, Joint Mathematics Meetings 2018, San Diego

"Persistence of sums of correlated increments and clustering in cellular automata", AMS Special Session on Markov chains, Markov processes and applications, Joint Mathematics Meetings 2018, San Diego

"Phase transition in a random soliton cellular automaton" Combinatorics and Probability Seminar, OSU, April 12, 2017

"Discrete excitable media on graphs" Probability Seminar, Indiana University, Sep 12, 2016

"Synchronization of finite-state pulse-coupled oscillators and applications to distributed algorithms" 2016 Combinatorics Conference, KAIST, Jul 23, 2016

"Synchronization of finite-state pulse-coupled oscillators on various network topologies" Hayes Graduate Research Forum, OSU, Feb 26, 2016

"Synchronization of finite-state pulse-coupled oscillators on various graphs" Probability Seminar, Cornell University, Feb 22, 2016

"Synchronization of finite-state pulse-coupled oscillators on various graphs" Korea Institute of Advanced Studies, Jan 14, 2016

"Synchronization of finite-state pulse-coupled oscillators" HYKE seminar, Seoul National University, May 14, 2015

"Synchronization of finite-state pulse-coupled oscillators on various network topologies" Combinatorics and Probability seminar, OSU, Oct 1, 2015

"Synchronization of finite-state pulse-coupled oscillators" Graduate Student Seminar, OSU, Sep 22, 2015

SUMMER REU MENTORED

Summer 2020: "*Machine Learning approaches to oscillators and clock synchronization*" ([link](#))

PI: Hanbaek Lyu

Team members: Hardeep Bassi, Rohith Kodukula, Josh Vendrow, Richard Yim, and Cherlin Zhu

Summer 2019: "*Sequence learning and building topic-aware chatbot using RNN and NMF*" ([link](#))

PI: Deanna Needell

Mentor: Hanbaek Lyu

Consultant: Blake Hunter

Team members: Henry Sojico, Nicholas Liskij, Nicholas Hanoian, Zhexiao Lin, Jiajiao Qu, Yuchen Guo, Yuliang Wang, Xiong Zhe, Zhenhong Zou

TEACHING

Lecture Notes [Graduate Probability I](#), [Undergraduate Probability](#)
[Stochastic Processes](#), [Mathematical Finance](#), [Introduction to Statistics II](#)

UW-Madison

Spring 2023: Math 535 (Mathematical Methods in Data Science)

Fall 2022: Math 733 (Probability Theory I)

Spring 2022: Math 431 (Introduction to Probability Theory)

Fall 2021: Math 631 (Stochastic Processes)

UCLA

Spring 2021: Math 156 (Machine Learning)

Winter 2021: Math 170S (Intro. to Probability and Statistics II)

Fall 2020: Math 170S (Intro. to Probability and Statistics II) — Course coordinator

Summer 2020 C: Math 170S (Intro. to Probability and Statistics II), Math 174E (Mathematical Finance)

Spring 2020: Math 170S (Intro. to Probability and Statistics II)

Winter 2020: Math 171 (Stochastic processes), Math 170S (Intro. to Probability and Statistics II)

Summer 2019: Math 170A (Probability theory), Math 170B (Probability theory), Math 174E (Mathematical Finance)

Spring 2019: Math 170B (Probability theory)

Winter 2019: Math 170A (Probability theory), Math 171 (Stochastic Processes)

Fall 2018: Math 170B (Probability theory)

OSU

Fall 2015: Math 2153 (Calculus 3) ([Notes](#))

Spring 2014: Math 1131 (Calculus for business)

Fall 2014: Fall 2014: Math 1131 (Calculus for business)

Summer 2013: Summer 2013: Math 1152 (Calculus 2)

Spring 2013: Spring 2013: Math 1151 (Calculus 1)

Fall 2013: Math 1151 (Calculus 1)

AWARDS AND FELLOWSHIPS

The Ohio State University Presidential Fellowship (University research fellowship), Spring 2017 - Fall 2017

Special Graduate Associate (Departmental research fellowship), Fall 2016

Special Graduate Associate (Departmental research fellowship), Spring 2016

National Science & Technology Scholarship, 2008-2012