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Mikhail Belkin — Curriculum Vitae

Research Interests

- Mathematical, statistical and computational foundations and limitations of learning from data.
- Machine learning, statistical analysis of natural data and applications.
- Spectral, manifold and kernel methods for machine learning.
- Semi-supervised learning and clustering.
- Scalable implementations.

Academic Experience

- Ohio State University, Professor,
Department of Computer Science and Engineering,
Department of Statistics (courtesy appointment), 2017 – present.
- Simons Institute for the Theory of Computing, Berkeley,
Visiting Faculty, Jan 2017 – May 2017.
- The Institute of Science and Technology (IST Austria),
Visiting Professor, Sept 2012 – May 2013.
- Ohio State University, Associate Professor,
Department of Computer Science and Engineering,
Department of Statistics (courtesy appointment), 2011 – 2017.
- Statistical and Applied Mathematical Sciences Institute (SAMSI),
Research Fellow, Jan 2007 – March 2007.
- Ohio State University, Assistant Professor,
Department of Computer Science and Engineering,
Department of Statistics (courtesy appointment), 2005 – 2011.
- University of Chicago, Department of Computer Science,
Postdoctoral Researcher, Dec 2003 – Aug 2005.
- Institute for Pure and Applied Mathematics, UCLA,
Multiscale Geometry and Analysis in High Dimensions, Fall 2004.
- University of California, Berkeley, Department of Statistics,
Visiting Research Fellow, Feb – Mar 2004.
- Max Planck Institute for Biological Cybernetics, Tübingen,
Research Scientist, Aug – Dec 2003.

Degrees and Education

- The University of Chicago, Ph.D. in Mathematics, 2003.
Thesis: Problems of Learning on Manifolds.
Thesis adviser: Partha Niyogi.
- The University of Chicago, M.Sc. in Mathematics, 1997.
- The University of Toronto, Hon.B.Sc. with High Distinction,
Major in Mathematics, 1995.

Grants, Awards and Scholarships

- NSF: RI: Small: Learning discrete structure from continuous spaces (PI), 2017-2020.
- NSF: Collaborative research: NCS-FO: Learning efficient visual representations from realistic environments across time scales (co-I), 2016-2020.
- NSF IIS:EAGER:The exploration of geometric and non-geometric structure in data (PI), 2015-2017.
- NSF CCF: Small: Geometry and High-dimensional Inference (co-PI), 2014-2017.
- NSF RI: Small: Algebraic and Spectral Structure of Data in High Dimension (single PI), 2011-2015.
- Lumley Research Award, College of Engineering, Ohio State University, 2011.
- NSF EAGER, Integration of Computational Geometry and Statistical Learning for Modern Data Analysis (co-PI), 2010 – 2012.
- AFOSR, Networks of Memories (co-PI), 2009 – 2012.
- NSF Conference Grant, 2009 Machine Summer School on Computational Learning (single PI), 2009.
- NSF Early Career Award: Geometry and High-dimensional Inference, 2007 – 2012.
- NSF/DARPA Computational and Algorithmic Representation of Geometric Objects incubatory grant (Senior Personnel), 2003 – 2004.
- University Fellowship, University of Chicago, 1996 – 1997.
- National Science and Eng. Research Council of Canada Postgraduate Scholarship, 1995 – 1997.
- Several merit-based undergraduate scholarships and awards, including Galois Award in Mathematics, Ted Mossman Scholarship, Alfred T. Delury Scholarship in Mathematics, Samuel Beatty Award.
- Moscow Mathematical Olympiad, second prize, 1990.

Industry Experience

- University Community Healthcare, Chicago.
– Senior Software Engineer, 1998 – 2000.

Publications: Journal Papers/Preprints

- *Learning kernels that adapt to GPU*,
Siyuan Ma, Mikhail Belkin.
- *Overfitting or perfect fitting? Risk bounds for classification and regression rules that interpolate*,
Mikhail Belkin, Daniel Hsu, Partha Mitra.

- *Eigenvectors of orthogonally decomposable functions*, Mikhail Belkin, Luis Rademacher, James Voss, SIAM Journal on Computing (SICOMP), 2018.
- *Polynomial learning of distribution families*, Mikhail Belkin, Kaushik Sinha, SIAM Journal on Computing (SICOMP),44(4), 889-911, 2015.
- *Robust features for the automatic identification of autism spectrum disorder in children*, Justin Eldridge, Alison Lane, Mikhail Belkin, Simon Dennis, Journal of Neurodevelopmental Disorders, 2014.
- *The Geometry and Dynamics of Lifelogs: Discovering the Organizational Principles of Human Experience*, Vishnu Sreekumar, Simon Dennis, Isidoros Doxas, Yuwen Zhuang, Mikhail Belkin, PLOS One, 2014.
- *Heat flow and a faster algorithm to compute the surface area of a convex body*, M. Belkin, H. Narayanan, P. Niyogi, Random Structures & Algorithms, 43: 407428, 2013.
- *Laplacian Support Vector Machines Trained in the Primal*, S. Melacci, M. Belkin, The Journal of Machine Learning Research,12:1149–1184, 2011.
- *On Learning with Integral Operators*, L. Rosasco, M. Belkin, E. de Vito, The Journal of Machine Learning Research, 11(Feb):905934, 2010.
- *Data Spectroscopy: Eigenspaces of Convolution Operators and Clustering*, Tao Shi, Mikhail Belkin, Bin Yu, The Annals of Statistics, vol. 37, Number 6B (2009), 3960-3984.
- *Towards a Theoretical Foundation for Laplacian-Based Manifold Methods*, M. Belkin, P. Niyogi, Journal of Computer and System Sciences, Volume 74 , Issue 8 (December 2008), pp. 1289-1308 Special Issue on Learning Theory, invited.
- *Consistency of Spectral Clustering*, U. von Luxburg, M. Belkin, O. Bousquet, The Annals of Statistics, 2008, Vol. 36, No. 2, 555-586.
- *Manifold Regularization: a Geometric Framework for Learning from Examples*, M. Belkin, P. Niyogi, V. Sindhwani, Journal of Machine Learning Research, 7(Nov):2399–2434, 2006.
- *Semi-supervised Learning on Riemannian Manifolds*, M. Belkin, P. Niyogi, Machine Learning, 56, 209-239, 2004. Special issue on clustering, invited.
- *Laplacian Eigenmaps for Dimensionality Reduction and Data Representation*, M. Belkin, P. Niyogi, Neural Computation, June 2003; 15 (6):1373-1396.

Refereed Conference Proceedings

- *To understand deep learning we need to understand kernel learning*, Mikhail Belkin, Siyuan Ma, Soumik Mandal, ICML 2018.
- *The power of interpolation: effectiveness of SGD in modern over-parametrized learning*, Siyuan Ma, Raef Bassily, Mikhail Belkin, ICML 2018.
- *Approximation beats concentration? An approximation view on inference with smooth kernel*, Mikhail Belkin, COLT 2018.
- *Unperturbed: spectral analysis beyond Davis-Kahan*, Justin Eldridge, Mikhail Belkin, Yusu Wang, ALT 2018.
- *Diving into the shallows: a computational perspective on large-scale shallow learning*, Siyuan Ma, Mikhail Belkin, Neural Information Processing Systems (NIPS), 2017 (spotlight presentation, 5% of submissions).
- *Graphons, mergeons, and so on!* Justin Eldridge, Mikhail Belkin, Yusu Wang, Neural Information Processing Systems (NIPS), 2016 (oral presentation, 2% of submissions).
- *Clustering with Bregman Divergences: an Asymptotic Analysis*, Chaoyue Liu, Mikhail Belkin, Neural Information Processing Systems (NIPS), 2016.
- *Learning a Hidden Basis Through Imperfect Measurements: An Algorithmic Primitive*, M. Belkin, L. Rademacher, J. Voss, The 29th Conference on Learning Theory (COLT), 2016.
- *Learning Privately from Multiparty Data*, J. Hamm, P. Cao, and M. Belkin, International Conference on Machine Learning (ICML), 2016
- *Back to the Future: Radial Basis Networks Revisited*, Qichao Que, Mikhail Belkin, The 19th International Conference on Artificial Intelligence and Statistics (AISTATS), 2016.
- *The Hidden Convexity of Spectral Clustering*, James Voss, Mikhail Belkin, Luis Rademacher, Thirtieth AAAI Conference on Artificial Intelligence (AAAI-16), 2016, oral presentation.
- *Beyond Hartigan Consistency: Merge Distortion Metric for Hierarchical Clustering*, Justin Eldridge, Mikhail Belkin, Yusu Wang, The 28th Conference on Learning Theory (COLT), 2015, **Mark Fulk award** (best student paper).
- *A Pseudo-Euclidean Iteration for Optimal Recovery in Noisy ICA*, James Voss, Mikhail Belkin, Luis Rademacher, Neural Information Processing Systems (NIPS), 2015.
- *Crowd-ML: A Learning Framework For A Crowd of Smart Devices*, J. Hamm, A. Champion, G. Chen, M. Belkin, and D. Xuan, IEEE International Conference on Distributed Computing Systems (ICDCS), 2015.

- *Learning with Fredholm Kernels*,
Qichao Que, Mikhail Belkin, Yusu Wang
Neural Information Processing Systems (NIPS), 2014.
- *The More, the Merrier: the Blessing of Dimensionality for Learning Large Gaussian Mixtures*,
Joseph Anderson, Mikhail Belkin, Navin Goyal, Luis Rademacher, James Voss,
The 27th Conference on Learning Theory (COLT 2014).
- *Inverse Density as an Inverse Problem: The Fredholm Equation Approach*,
Qichao Que, Mikhail Belkin,
Neural Information Processing Systems (NIPS), spotlight presentation, 2013.
- *Fast Algorithms for Gaussian Noise Invariant Independent Component Analysis*,
James Voss, Luis Rademacher, Mikhail Belkin,
Neural Information Processing Systems (NIPS), 2013.
- *Blind Signal Separation in the Presence of Gaussian Noise*,
Mikhail Belkin, Luis Rademacher, James Voss,
The 26th Conference on Learning Theory (COLT 2013).
- *Toward understanding complex spaces: graph Laplacians on manifolds with singularities and boundaries*,
M. Belkin, Q. Que, Y. Wang, X. Zhou,
The 25th Conference on Learning Theory (COLT 2012).
- *Recognizing Daily Contexts from Multisensory Data: A Codebook Approach*,
J. Hamm, B. Stone, M. Belkin, S. Dennis,
Fourth Int. Conference on Mobile Computing, Applications and Services (MOBICASE), 2012
- *Data Skeletonization via Reeb Graphs*,
X. Ge, I. Safa, M. Belkin, Y. Wang,
Twenty-Fifth Annual Conference on Neural Information Processing Systems (NIPS), 2011.
- *An Iterated Graph Laplacian Approach for Ranking on Manifolds*,
X. Zhou, M. Belkin, N. Srebro,
17th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD), 2011.
- *Semi-supervised Learning by Higher Order Regularization* ,
X. Zhou, M. Belkin,
14th International Conference on Artificial Intelligence and Statistics (AISTATS), 2011.
- *Polynomial Learning of Distribution Families*,
M. Belkin, K. Sinha,
51st Annual IEEE Symposium on Foundations of Computer Science (FOCS), 2010.
- *Toward Learning Gaussian Mixtures with Arbitrary Separation*,
M. Belkin, K. Sinha,
The 23rd Annual Conference on Learning Theory (COLT), 2010.
- *Learning speaker normalization using semisupervised manifold alignment*,
A. Plummer, M. Beckman, M. Belkin, E. Fosler-Lussier, and B. Munson,
Proc. Interspeech, 2010.

- *Semi-supervised Learning Using Sparse Eigenfunction Bases*,
K. Sinha, M. Belkin,
Twenty-Third Annual Conference on Neural Information Processing Systems (NIPS), 2009.
- *A Note on Learning with Integral Operators*,
L. Rosasco, M. Belkin, E. de Vito,
The 22nd Annual Conference on Learning Theory (COLT), 2009.
- *Constructing Laplace Operator from Point Clouds in \mathbf{R}^d*
M. Belkin, J. Sun, Y. Wang,
ACM-SIAM Symposium on Discrete Algorithms (SODA), 2009.
- *Data Spectroscopy: Learning Mixture Models using Eigenspaces of Convolution Operators*,
T. Shi, M. Belkin, B. Yu,
The 25th International Conference on Machine Learning (ICML), 2008.
- *Component Based Shape Retrieval Using Differential Profiles*,
L. Ding, M. Belkin,
ACM International Conference on Multimedia Information Retrieval (MIR), 2008.
- *Probabilistic Mixtures of Differential Profiles for Shape Recognition*,
L. Ding, M. Belkin,
The 19th International Conference on Pattern Recognition (ICPR), 2008.
- *Discrete Laplace Operator for Meshed Surfaces*,
M. Belkin, J. Sun, Y. Wang,
The 24th Annual Symposium on Computational Geometry (SOCG), 2008.
- *The Value of Labeled and Unlabeled Examples when the Model is Imperfect*,
K. Sinha, M. Belkin, 21st Annual Conference on Neural Information Processing Systems (NIPS),
spotlight presentation, 2007.
- *Convergence of Laplacian Eigenmaps*,
M. Belkin, P. Niyogi,
Twentieth Annual Conference on Neural Information Processing Systems (NIPS), 2006.
- *On the Relation Between Low Density Separation, Spectral Clustering and Graph Cuts*,
H. Narayanan, M. Belkin, P. Niyogi,
Twentieth Annual Conference on Neural Information Processing Systems (NIPS), 2006.
- *Heat Flow and a Faster Algorithm to Compute the Surface Area of a Convex Body*,
M. Belkin, H. Narayanan, P. Niyogi,
47th Annual IEEE Symposium on Foundations of Computer Science (FOCS), 2006.
- *Maximum Margin Semi-Supervised Learning for Structured Variables*,
Y. Altun, D. McAllester, M. Belkin,
Nineteenth Annual Conference on Neural Information Processing Systems (NIPS), 2005.
- *Beyond the Point Cloud: from Transductive to Semi-supervised Learning* ,
V. Sindhwani, P. Niyogi, M. Belkin,
The 22nd International Conference on Machine Learning (ICML) 2005.

- *Towards a Theoretical Foundation for Laplacian-based Manifold Methods*
M. Belkin, P. Niyogi, The Eighteenth Annual Conference on Learning Theory (COLT), 2005.
- *On Manifold Regularization*,
M. Belkin, P. Niyogi, V. Sindhwani,
The Tenth International Workshop on Artificial Intelligence and Statistics (AISTATS), 2005.
- *Limits of Spectral Clustering*,
U. von Luxburg, O. Bousquet, M. Belkin,
Neural Information Processing Systems (NIPS), 2004, **outstanding student paper award**.
- *Regularization and Semi-Supervised Learning on Large Graphs*,
M. Belkin, I. Matveeva, P. Niyogi,
The Seventeenth Annual Conference on Learning Theory (COLT), 2004.
- *On the Convergence of Spectral Clustering on Random Samples: the Normalized Case*,
U. von Luxburg, O. Bousquet, M. Belkin,
The Seventeenth Annual Conference on Learning Theory (COLT), 2004.
- *Tikhonov Regularization and Semi-Supervised Learning on Large Graphs* (Invited),
M. Belkin, I. Matveeva, P. Niyogi,
2004 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2004),
Special Session: Manifolds and Geometry and Signal Processing, 2004.
- *Using Manifold Structure for Partially Labeled Classification*,
M. Belkin, P. Niyogi,
Sixteenth Annual Conference on Neural Information Processing Systems (NIPS), 2002.
- *Using Eigenvectors of the Bigram Graph to Infer Morpheme Identity*,
M. Belkin, J. Goldsmith,
Proceedings of the Morphology/Phonology Learning Workshop of ACL-02, Association for Computational Linguistics, 2002.
- *Laplacian Eigenmaps and Spectral Techniques for Embedding and Clustering*,
M. Belkin, P. Niyogi,
Fifteenth Annual Conference on Neural Information Processing Systems (NIPS), 2001.

Book Chapters

- *Semi-Supervised Learning*, Xueyuan Zhou, Mikhail Belkin,
Academic Press Library in Signal Processing:
Signal Processing Theory and Machine Learning, 2013.
- *The Geometric Basis of Semi-supervised Learning*,
V. Sindhwani, M. Belkin, P. Niyogi,
Semi-supervised Learning (Chapelle, Schoelkopf, Zien: editors), MIT Press, 2006.

Ph.D. Thesis

- *Problems of Learning on Manifolds*, University of Chicago, Department of Mathematics, 2003.
Thesis adviser: Partha Niyogi.

Conference (co-)organizer

- Midwest ML Symposium, University of Chicago/TTIC, 2017.
- Information Modeling and Control of Complex Systems Workshop, Ohio State University, 2016, 2017.
- Simons Institute Workshop on Spectral Algorithms: From Theory to Practice (co-chair), 2014.
- Partha Niyogi Memorial Conference, The University of Chicago, 2011.
- 2010 SDM (Siam Int. Conference on Data Mining) Workshop on Clustering: Theory and applications.
- 2009 AAI Fall Symposium on Manifold Learning.
- 2009 Machine Learning Summer School/Workshop on Theory and Practice of Comput. Learning.
- Workshop on Geometry, Random Matrices, and Statistical Inference, SAMSI, Jan 2007.
- 2005 Chicago Machine Learning Summer School.

Recent Editorial and Program Committee Service

- The Journal of Machine Learning Research, Action Editor, 2011 – 2018.
- IEEE Transactions on Pattern Recognition and Machine Intelligence, Associate Editor, 2011 – 2016.
- Area Chair for NIPS 2018.
- COLT 2018.
- Area Chair for ICML 2018.
- Area Chair for ICML 2017.
- AAI 2017 (SPC).
- COLT 2016.
- AI and Statistics 2015 (SPC).
- Area chair for NIPS 2014.
- AAI 2014.
- Area chair for ICML 2014.
- COLT 2013.
- Area chair for NIPS 2011.
- Area chair for NIPS 2010.
- Local chair for SDM 2010.
- COLT 2010.
- Area chair for ICML 2010.
- AI and Statistics 2010.

Refereed and served on panels/program committees for:

- The Annals of Statistics, Science, IEEE Transactions on Pattern Analysis and Machine Intelligence, Bernoulli, ACM Transactions on Sensor Networks, IEEE Transactions on Image Processing, PNAS, IEEE Transactions on Signal Processing, International Journal of Computer Vision, Machine Learning Journal, Journal of Machine Learning Research, Journal of the American Statistical Association (JASA), Pattern Recognition, FOCS, NIPS, ICML, COLT, AISTATS, AAI, ICCV, AFOSR, NSF, RGC Hong Kong, US-Israel Binational Science Foundation.

Recent Invited Talks and Tutorials

- ORFE colloquium, Princeton University, Feb 2018.
- Information Theory and Application Workshop, San Diego, Feb 2018.
- Workshop on Inverse Problems in Machine Learning, Caltech, Jan 2018.
- Workshop on Computational Brain Research at IIT Madras, Chennai, India, Jan 2018.
- Simons Institute, Workshop on Optimization Statistics and Uncertainty, Berkeley, Nov 2017.
- University of Chicago, Computer Science, Nov 2017.
- NCState, Workshop on Data Science, Nov 2017.
- NYU, CS, New York, Oct 2017.
- APS INFORMS, Chicago, July 2017.
- ENSAE, CREST, Paris, France, June 2017.
- Workshop on statistical aspects of geometric and topological data anal., Banyuls, France, June 2017.
- Neymann Seminar, Statistics, University of California Berkeley, May 2017.
- Simons Institute, Berkeley, Apr 2017.
- UCLA CS Colloquium, Apr 2017.
- Oberwolfach workshop on Statistical Recovery of Discrete, Geometric and Invariant Structures, Apr 2017.
- Information Theory and Application Workshop, San Diego, Feb 2017.
- Workshop on Computational Brain Research at IIT Madras, Chennai, India, Jan 2017.
- IDSS Statistics and Stochastics Seminar, MIT, Oct 2016.
- Data Science Initiative (DSI) Colloquium, Boston University, 2016.
- ICML 2016 Workshop on Geometry in Machine Learning, June 2016.
- Simons Institute for Data Analysis, NYC, June 2016.
- Wilks Statistics Seminar, ORFE, Princeton University, March 2016.
- Shape Analysis and Learning by Geometry and Machine, IPAM, UCLA, Feb 2016.
- Information Theory and Application Workshop, San Diego, Feb 2016.
- Workshop on Computational Brain Research at IIT Madras, Chennai, India, Jan 2016.
- Penn State Statistics Colloquium, Oct 2015.
- Conference on Geometry and Data Analysis, University of Chicago, June 2015.
- Groups and interactions in data, networks and biology, Carnegie Mellon University, May 2015.
- Information Theory, Learning and Big Data, Simons Institute, Berkeley, Mar 2015.
- Neymann Seminar, Statistics, University of California Berkeley, Mar 2015.
- Information Theory and Applications Workshop, San Diego, Feb 2015.
- Foundations of Computational Mathematics (FOCM 2014), Workshop on Learning Theory, Uruguay, Montevideo, Dec 2014.
- CIRM Meeting on Mathematical Statistics, Luminy, Dec 2014.
- MADALGO Summer School on Learning at Scale, Aarhus University, Denmark, Aug 2014.

- Duke University, Computer Science, May 2014.
- SAMSI LDHD Transition workshop, May 2014.
- Ohio State University, Mathematics, Topology, Geometry and Data Seminar, March 2014.
- Information Theory and Application, San Diego, Feb 2014.
- Conference on Numerical Analysis and Scientific Computing, Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany, Jan 2014.
- NIPS Workshop on Modern Nonparametrics, NIPS 2013, Dec 2013.
- Workshop on Learning Data Representation: Hierarchies and Invariance, MIT, Nov 2013.
- Workshop on Modern Applications of Homology and Cohomology, IMA, Minneapolis, Oct 2013.
- International conference on Geometry, Topology, and Applications, Yaroslavl, Russia, Sept 2013.
- Case Western University, CS Department, Sept 2013.
- ICML Workshop on Spectral Learning, Atlanta, June 2013.
- Ohio Innovation Sensor Summit, Workshop on Machine Learning and Emerging Applications, Dayton, June 2013.
- International Conference on Approximation Theory and Applications, Hong Kong, May 2013.
- Italian Institute of Technology, Genova, Italy, May 2013.
- Radon Institute, Linz, Austria, Apr 2013.
- Max Planck Institute for Intelligent Systems, Tübingen, Germany, Feb 2013.
- AMS Sectional Meeting, Special Session on Applied Topology, Akron, Oct 2012.
- BIRS Workshop on Topological Data Analysis and Machine Learning Theory, Banff, Oct 2012.
- Workshop on Algebraic Statistics, ISTA, Austria, Sept 2012.
- INRIA, Saclay, France Sept 2012.
- Yaroslavl International Conference on Discrete Geometry, Yaroslavl, Russia, Aug 2012.
- Summer School an Neuroinformatics, Marine Biological Laboratory, Woods Hole, Aug 2012.
- Mathematical Sciences Center, Tsinghua University, July 2012.
- International Conference on Geometry/Imaging, Kunming, China, July 2012.
- Oberwolfach workshop on Learning Theory and Approximation, June 2012.
- The University of Chicago Statistics Colloquium, Apr 2012.
- Oberwolfach mini-workshop on Mathematics of Machine Learning, Aug 2011.
- Summer School an Neuroinformatics, Marine Biological Laboratory, Woods Hole, Aug 2011.
- Dagstuhl Workshop on Mathematical and Computational Foundations of Learning Theory, July 2011.
- The Fourth International Conference on Computational Harmonic Analysis, Hong Kong, May 2011.
- MIT Brains and Machines Seminar, Apr 2011.