

# Bharath Kumar Sriperumbudur Vangeepuram

Department of Statistics  
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## Research Interests

Machine Learning, Statistical Learning Theory, Non-parametric Estimation, Regularization and Inverse Problems, Reproducing Kernel Spaces in Probability and Statistics, Functional Data Analysis, Topological Data Analysis, Optimal Transport and Gradient Flows

## Education

**University of California, San Diego** 09/2005–11/2010  
Ph.D., Electrical and Computer Engineering (emphasis in Machine Learning and Computational Statistics)  
Dissertation: *Reproducing Kernel Space Embeddings and Metrics on Probability Measures*  
Advisor: Prof. Gert R. G. Lanckriet

**Indian Institute of Technology, Kanpur, India** 08/2000– 03/2002  
M.Tech., Electrical Engineering (emphasis in Signal Processing)  
Thesis: *A Model Based Approach to Non-Uniform Vowel Normalization*  
Advisor: Prof. S. Umesh

**Sri Venkateswara University, Tirupati, India** 07/1995–06/1999  
B.Tech., Electronics and Communication Engineering

## Employment

### Academic Positions

**Department of Statistics, The Pennsylvania State University**  
Full Professor 07/2024–present  
Associate Professor 06/2020–06/2024  
Assistant Professor 08/2014–05/2020

**Department of Mathematics, The Pennsylvania State University**  
Full Professor (by courtesy) 07/2024–present  
Associate Professor (by courtesy) 01/2024–06/2024

**Statistical Laboratory, University of Cambridge** 09/2012–08/2014  
Research Fellow in Statistics

**Gatsby Computational Neuroscience Unit, University College London** 12/2010–09/2012  
Post-doctoral Research Associate

### Visiting Positions

**The Institute of Statistical Mathematics, Tokyo** 10/2012  
Host: Prof. Kenji Fukumizu

<b>National ICT Australia</b> , Canberra Host: Prof. Robert Williamson	10/2011
<b>Faculty of Mathematical Sciences, Queensland University of Technology</b> Host: Prof. Peter Bartlett (also with the Department of Statistics, University of California-Berkeley)	10/2011
<b>Institute for Stochastics and Applications, University of Stuttgart</b> Host: Prof. Dr. Ingo Steinwart	04/2011

### *Internships*

<b>The Institute of Statistical Mathematics</b> , Tokyo Advisor: Prof. Kenji Fukumizu	10–12/2009
<b>Max Planck Institute for Biological Cybernetics</b> , Tübingen Advisors: Prof. Dr. Bernhard Schölkopf and Dr. Arthur Gretton	2007/2008
<b>Swartz Center for Computational Neuroscience, University of California San Diego</b> Advisor: Dr. Scott Makeig	06–08/2006

### *Industry Positions*

<b>Imaging Technologies Lab, General Electric Global Research</b> , Bangalore, India Research Engineer	04/2002–08/2005
<b>Wipro Technologies</b> , Bangalore, India Systems Engineer	11/1999–07/2000

## Honors, Awards & Fellowships

Rosenberger Outstanding Teaching Award, Pennsylvania State University	2024
Simons Visiting Professor, Mathematisches Forschungsinstitut Oberwolfach, Germany	2023
NSF CAREER Award	2020
Travel Award, Fourth Conference of the International Society for Nonparametric Statistics, Salerno	2018
Travel Award, Third Conference of the International Society for Nonparametric Statistics, Avignon	2016
Travel Award, Spring School on “Structural Inference in Statistics”, Berlin	2014
Herman Goldstine Memorial Postdoctoral Fellowship in Mathematical Sciences, IBM Research <sup>1</sup>	2012
Travel Award, Workshop on “Machine Learning: Theory and Computation”, Institute for Mathematics and its Applications, University of Minnesota	2012
Honorable Mention, Best Student Paper, Twenty-Third Annual Conference on Neural Information Processing Systems	2009
Travel Award, Twenty-Third Annual Conference on Neural Information Processing Systems	2009
Travel Award, International Conference on Machine Learning	2007, 2008
Travel Award, Machine Learning Summer School, Tübingen	2007
Cal-(IT) <sup>2</sup> Fellowship, University of California, San Diego	2005–2006
Bronze Patent Medal, General Electric Global Research, Bangalore	2004
Hats-off Award, General Electric Global Research, Bangalore	2003
General Electric Scholarship	2000–2002

<sup>1</sup>Declined to accept the Research Fellow position at Statslab, University of Cambridge.

## Publications

Available for download from <http://www.personal.psu.edu/bks18/Publications.html>

### Monograph

1. Muandet, K., K. Fukumizu, B. K. Sriperumbudur and B. Schölkopf (2017). Kernel Mean Embedding of Distributions: A Review and Beyond. *Foundations and Trends in Machine Learning*, 10(1-2), 1–141.

### Journal Articles

1. Gupta, N., S. Sivanathan, and B. K. Sriperumbudur (2024). Optimal Rates for Functional Linear Regression with General Regularization. <https://arxiv.org/pdf/2406.10005.pdf>. *Applied and Computational Harmonic Analysis*. To appear.
2. Hagrass, O., B. K. Sriperumbudur and B. Li (2023). Spectral Regularized Kernel Goodness-of-Fit Tests. <http://arxiv.org/pdf/2308.04561.pdf>. *Journal of Machine Learning Research*. To appear.
3. Vishwanath, S., K. Fukumizu, S. Kuruki and B. K. Sriperumbudur (2022). On the Limits of Topological Data Analysis for Statistical Inference. <https://arxiv.org/pdf/2001.00220.pdf>. *Foundations of Data Science*. To appear.
4. Zhang, Z., Z. Goldfeld, Y. Mroueh and B. K. Sriperumbudur (2023). Gromov-Wasserstein Distances: Entropic Regularization, Duality and Sample Complexity. <https://arxiv.org/pdf/2212.12848.pdf>. *Annals of Statistics*. To appear.
5. He, Y., K. Balasubramanian, B. K. Sriperumbudur, and J. Lu (2022). Regularized Stein Variational Gradient Flow. <https://arxiv.org/pdf/2211.07861>. *Foundations of Computational Mathematics*. To appear.
6. Balasubramanian, K., H-G. Müller, and B. K. Sriperumbudur (2024). Functional Linear and Single-index Models: A Unified Approach via Gaussian Stein Identity. <https://arxiv.org/pdf/2206.03975.pdf>. *Bernoulli*. To appear.
7. Hagrass, O., B. K. Sriperumbudur and B. Li (2024). Spectral Regularized Kernel Two-Sample Tests. *Annals of Statistics*. 52(3): 1076–1101.
8. Utpala, S. and B. K. Sriperumbudur (2024). Shrinkage Estimation of Higher Order Bochner Integrals. *Bernoulli*. 30(4): 2721–2746.
9. Gupta, N., S. Sivanathan, and B. K. Sriperumbudur (2023). Convergence Analysis of Kernel Conjugate Gradient for Functional Linear Regression. *Journal of Applied and Numerical Analysis*. 1: 33–47.
10. Steinwart, I., B. K. Sriperumbudur and P. Thomann (2023). Adaptive Clustering using Kernel Density Estimators. *Journal of Machine Learning Research*. 24(275): 1–56.
11. Sheng, T. and B. K. Sriperumbudur (2023). On Distance and Kernel Measures of Conditional Dependence. *Journal of Machine Learning Research*, 24(7): 1–16.
12. Reimherr, M., B. K. Sriperumbudur and H. B. Kang (2023). Optimal Function-on-Scalar Regression over Complex Domains. *Electronic Journal of Statistics*, 17(1): 156–197.
13. Sterge, N. and B. K. Sriperumbudur (2022). Statistical Optimality and Computational Efficiency of Nyström Kernel PCA. *Journal of Machine Learning Research*, 23(337): 1–32.
14. Sriperumbudur, B. K. and N. Sterge (2022). Approximate Kernel PCA Using Random Features: Computational vs. Statistical Trade-off. *Annals of Statistics*, 50(5): 2713–2736.
15. Lam-Weil, J., A. Carpentier and B. K. Sriperumbudur (2022). Local minimax rates for closeness testing of discrete distributions. *Bernoulli*, 28(2): 1179–1197.

16. Kanagawa, M., B. K. Sriperumbudur and K. Fukumizu (2020). Convergence Analysis of Deterministic Kernel-based Quadrature Rules in Misspecified Settings. *Foundations of Computational Mathematics*, 20: 155–194.
17. Reimherr, M., B. K. Sriperumbudur and B. Taoufik (2018). Optimal Prediction for Additive Function-on-function Regression. *Electronic Journal of Statistics*, 12(2), 4571–4601.
18. Szabó, Z. and B. K. Sriperumbudur (2018). Characteristic and Universal Tensor Product Kernels. *Journal of Machine Learning Research*, 18(233), 1–29.
19. Tolstikhin, I., B. K. Sriperumbudur and K. Muandet (2017). Minimax Estimation of Kernel Mean Embeddings. *Journal of Machine Learning Research*, 18(86), 1–47.
20. Sriperumbudur, B. K., K. Fukumizu, R. Kumar, A. Gretton, and A. Hyvärinen (2017). Density Estimation in Infinite Dimensional Exponential Families. *Journal of Machine Learning Research*, 18(57), 1–59.
21. Szabó, Z., B. K. Sriperumbudur, B. Póczos and A. Gretton (2016). Learning Theory for Distribution Regression. *Journal of Machine Learning Research*, 17(152), 1–40.
22. Muandet, K., B. K. Sriperumbudur, K. Fukumizu, A. Gretton and B. Schölkopf (2016). Kernel Mean Shrinkage Estimators. *Journal of Machine Learning Research*, 17(48), 1–41.
23. Sriperumbudur, B. K. (2016). On the Optimal Estimation of Probability Measures in Weak and Strong Topologies. *Bernoulli*, 22(3): 1839–1893.
24. Sejdinovic, D., B. K. Sriperumbudur, A. Gretton and K. Fukumizu (2013). Equivalence of Distance-based and RKHS-based Statistics in Hypothesis Testing. *Annals of Statistics*, 41(5): 2263–2291.
25. Sriperumbudur, B. K., K. Fukumizu, A. Gretton, B. Schölkopf and G. R. G. Lanckriet (2012). On the Empirical Estimation of Integral Probability Metrics. *Electronic Journal of Statistics*, 6: 1550–1599.
26. Sriperumbudur, B. K. and G. R. G. Lanckriet (2012). A Proof of Convergence of the Concave-Convex Procedure Using Zangwill’s Theory. *Neural Computation*, 24(6): 1391–1407.
27. Sriperumbudur, B. K., K. Fukumizu and G. R. G. Lanckriet (2011). Universality, Characteristic Kernels and RKHS Embedding of Measures. *Journal of Machine Learning Research*, 12(Jul): 2389–2410.
28. Sriperumbudur, B. K., D. A. Torres and G. R. G. Lanckriet (2011). A Majorization-Minimization Approach to the Sparse Generalized Eigenvalue Problem. *Machine Learning*, 85(1): 3–39.
29. Sriperumbudur, B. K., A. Gretton, K. Fukumizu, B. Schölkopf and G. R. G. Lanckriet (2010). Hilbert Space Embeddings and Metrics on Probability Measures. *Journal of Machine Learning Research*, 11(Apr): 1297–1322.
30. Gretton, A., K. Fukumizu and B. K. Sriperumbudur (2009). Discussion of: Brownian Distance Covariance. *The Annals of Applied Statistics*, 3(4): 1285–1294.
31. Bharath Kumar, S. V. and S. Umesh (2008). Non-Uniform Speaker Normalization Using Affine Transformation. *Journal of the Acoustic Society of America*, 124(3): 1727–1738.

### Under Submission

1. Zhang, Z., Z. Goldfeld, K. Greenewald, Y. Mroueh and B. K. Sriperumbudur (2023). Gradient Flows and Riemannian Structure in the Gromov-Wasserstein Geometry. <https://arxiv.org/pdf/2407.11800.pdf>.
2. Kalinke, F., Z. Szabó, and B. K. Sriperumbudur (2024). Nyström Kernel Stein Discrepancy. <https://arxiv.org/pdf/2406.08401.pdf>.
3. Hagrass, O., B. K. Sriperumbudur and K. Balasubramanian (2024). Minimax Optimal Goodness-of-Fit Testing with Kernel Stein Discrepancy. <http://arxiv.org/pdf/2404.08278.pdf>.

4. Zonghao, C., A. Mustafi, P. Glaser, A. Gretton, A. Korba and B. K. Sriperumbudur (2024). (De)-regularized Maximum Mean Discrepancy Gradient Flow. <https://arxiv.org/pdf/2409.14980.pdf>.
5. Arya, S. and B. K. Sriperumbudur (2023). Kernel  $\epsilon$ -Greedy for Contextual Bandits. <https://arxiv.org/pdf/2306.17329.pdf>.
6. Siapoutis, N., D. Richards and B. K. Sriperumbudur (2022). Mean Shrinkage Estimation for High-Dimensional Diagonal Natural Exponential Families. <https://arxiv.org/pdf/2010.08071.pdf>.
7. Vishwanath, S., B. K. Sriperumbudur, K. Fukumizu, and S. Kuruki (2022). Robust Topological Inference in the Presence of Outliers. <https://arxiv.org/pdf/2206.01795.pdf>.
8. Kangawa, M., P. Henning, D. Sejdinovic and B. K. Sriperumbudur (2018). Gaussian Processes and Kernel Methods: A Review on Connections and Equivalences. <https://arxiv.org/pdf/1807.02582.pdf>.
9. Singh, S., B. K. Sriperumbudur and B. Póczos (2020). Minimax Estimation of Quadratic Fourier Functionals. <https://arxiv.org/pdf/1803.11451.pdf>.

### Peer Reviewed Conference Papers

1. Zhang, Z., Y. Mroueh, Z. Goldfeld and B. K. Sriperumbudur (2022). Cycle Consistent Probability Divergences Across Different Spaces. In *Proceedings of the 24th International Conference on Artificial Intelligence and Statistics*. (Accepted: 492/1685, 29%)
2. Vishwanath, S., K. Fukumizu, S. Kuruki and B. K. Sriperumbudur (2020). Robust Persistence Diagrams Using Reproducing Kernels. In *Advances in Neural Information Processing Systems* 34. (Accepted: 1900/9454, 20%)
3. Kpotufe, S. and B. K. Sriperumbudur (2020). Gaussian Sketching yields J-L Lemma in RKHS. In *Proceedings of the 23rd International Conference on Artificial Intelligence and Statistics*, Palermo, Italy.
4. Sterge, N., B. K. Sriperumbudur, L. Rosasco and A. Rudi (2020). Gain with No Pain: Efficient Kernel PCA by Nyström Sampling. In *Proceedings of the 23rd International Conference on Artificial Intelligence and Statistics*, Palermo, Italy.
5. Szabó, Z. and B. K. Sriperumbudur (2019). On Kernel Derivative Approximation with Random Fourier Features. In *Proceedings of the 22nd International Conference on Artificial Intelligence and Statistics*, Okinawa, Japan. (Accepted: 360/1111, 32%)
6. Tolstikhin, I., B. K. Sriperumbudur and B. Schölkopf (2016). Minimax Estimation of Maximal Mean Discrepancy with Radial Kernels. In *Advances in Neural Information Processing Systems* 28. (Accepted: 568/2500, 23%)
7. Kanagawa, M., B. K. Sriperumbudur and K. Fukumizu (2016). Convergence Guarantees for Kernel-Based Quadrature Rules in Misspecified Settings. In *Advances in Neural Information Processing Systems* 28. (Accepted: 568/2500, 23%)
8. Sriperumbudur, B. K. and Z. Szabó (2015). Optimal Rates for Random Fourier Features. In *Advances in Neural Information Processing Systems* 27. (Accepted for spotlight: 67/1838, 4%; Overall: 403/1838, 22%)
9. Szabó, Z., A. Gretton, B. Póczos and B. K. Sriperumbudur (2015). Two-stage Sampled Learning Theory on Distributions. In *Proceedings of the 18th International Conference on Artificial Intelligence and Statistics*, San Diego, USA. (Accepted for plenary oral: 27/442, 6%; Overall: 127/442, 29%)
10. Muandet, K., B. K. Sriperumbudur and B. Schölkopf (2014). Kernel Mean Estimation via Spectral Filtering. In *Advances in Neural Information Processing Systems* 27. (Accepted: 370/1467, 25%)
11. Muandet, K., K. Fukumizu, B. K. Sriperumbudur, A. Gretton and B. Schölkopf (2014). Kernel Mean Estimation and Stein's Effect. In *Proceedings of the 31st International Conference on Machine Learning*, Beijing, China. (Accepted: 310/1238, 25%)

12. Kar, P., B. K. Sriperumbudur, P. Jain and H. Karnick (2013). On the generalization ability of online learning algorithms for pairwise loss functions. In *Proceedings of the 30th International Conference on Machine Learning*, Atlanta, USA.
13. Balasubramanian, K., B. K. Sriperumbudur and G. Lebanon (2013). Ultrahigh Dimensional Feature Screening Using RKHS Embeddings. In *Proceedings of the 16th International Conference on Artificial Intelligence and Statistics*, 126–134, Scottsdale, Arizona, USA. (Accepted: 71/211, 34%)
14. Gretton, A., B. K. Sriperumbudur, D. Sejdinovic, H. Strathmann, S. Balakrishnan, M. Pontil and K. Fukumizu (2012). Optimal Kernel Choice for Large-Scale Two-Sample Tests. In *Advances in Neural Information Processing Systems* 25. (Accepted: 370/1467, 25%)
15. Sejdinovic, D., A. Gretton, B. K. Sriperumbudur and K. Fukumizu (2012). Hypothesis Testing Using Pairwise Distances and Associated Kernels. In *Proceedings of the 29th International Conference on Machine Learning*, 1111–1118. (Accepted: 243/890, 27%)
16. Sriperumbudur, B. K. and I. Steinwart (2012). Consistency and Rates for Clustering with DBSCAN. In *Proceedings of the 15th International Conference on Artificial Intelligence and Statistics*, 1090–1098, La Palma, Canary Islands. (Accepted: 134/400, 34%)
17. Sriperumbudur, B. K., K. Fukumizu and G. R. G. Lanckriet (2011). Learning in Hilbert vs. Banach Spaces: A Measure Embedding Viewpoint. In *Advances in Neural Information Processing Systems* 24. (Accepted: 305/1400, 22%)
18. Sriperumbudur, B. K. (2011). Mixture Density Estimation Via Hilbert Space Embedding of Measures. In *Proceedings of the 2011 IEEE International Symposium on Information Theory*, 1027–1030, St. Petersburg, Russia.
19. Sriperumbudur, B. K., K. Fukumizu, A. Gretton, B. Schölkopf and G. R. G. Lanckriet (2010). Non-Parametric Estimation of Integral Probability Metrics. In *Proceedings of the 2010 IEEE International Symposium on Information Theory*, 1428–1432, Austin, Texas.
20. Sriperumbudur, B. K., K. Fukumizu and G. R. G. Lanckriet (2010). On the Relation Between Universality, Characteristic Kernels and RKHS Embedding of Measures. In *Proceedings of the 13th International Conference on Artificial Intelligence and Statistics*, 773–780, Sardinia, Italy. (Accepted for plenary oral: 24/308, 8%; Overall: 125/308, 41%)
21. Jegelka, S., A. Gretton, B. Schölkopf, B. K. Sriperumbudur and U. von Luxburg (2009). Generalized Clustering via Kernel Embeddings. In *Proceedings of the 32nd Annual German Conference on Artificial Intelligence*, 144–152, Paderborn, Germany.
22. Sriperumbudur, B. K., K. Fukumizu, A. Gretton, G. R. G. Lanckriet and B. Schölkopf (2009). Kernel Choice and Classifiability for RKHS Embeddings of Probability Distributions. In *Advances in Neural Information Processing Systems* 22. (Accepted for plenary oral: 22/1105, 2%; Overall: 263/1105, 24%)  
**Honorable Mention for the Outstanding Student Paper Award**
23. Sriperumbudur, B. K. and G. R. G. Lanckriet (2009). On the Convergence of the Concave-Convex Procedure. In *Advances in Neural Information Processing Systems* 22. (Accepted: 263/1105, 24%)
24. Gretton, A., K. Fukumizu and Z. Harchaoui, B. K. Sriperumbudur (2009). A Fast, Consistent Kernel Two-sample Test. In *Advances in Neural Information Processing Systems* 22. (Accepted for poster spotlight: 64/1105, 6%; Overall: 263/1105, 24%)
25. Fukumizu, K., B. K. Sriperumbudur, A. Gretton and B. Schölkopf (2008). Characteristic Kernels on Groups and Semigroups. In *Advances in Neural Information Processing Systems* 21. (Accepted for plenary oral: 32/1022, 3%; Overall: 250/1022, 24%)
26. Schölkopf, B., B. K. Sriperumbudur, A. Gretton and K. Fukumizu (2008). RKHS Representation of Measures applied to Homogeneity, Independence and Fourier Optics. In *Oberwolfach Report 30*, Mathematisches Forschungsinstitut, Oberwolfach-Walke, Germany.

27. Sriperumbudur, B. K., A. Gretton, K. Fukumizu, G. R. G. Lanckriet and B. Schölkopf (2008). Injective Hilbert Space Embeddings of Probability Measures. In *Proceedings of the 21st Annual Conference on Learning Theory*, 111–122, Helsinki, Finland. (Accepted: 44/126, 35%)
28. Sriperumbudur, B. K., O. A. Lang and G. R. G. Lanckriet (2008). Metric Embedding for Kernel Classification Rules. In *Proceedings of the 25th International Conference on Machine Learning*, 1008–1015, Helsinki, Finland. (Accepted: 158/583, 27%)
29. Sriperumbudur, B. K., D. A. Torres and G. R.G. Lanckriet (2007). Sparse Eigen Methods by D.C. Programming. In *Proceedings of the 24th International Conference on Machine Learning*, 831–838, Corvallis, Oregon, USA. (Accepted: 152/522, 29%)
30. Bharath Kumar, S. V., S. Umesh and R. Sinha (2006). Study of Non-Linear Frequency Warping Functions for Speaker Normalization. In *Proceedings of the 2006 IEEE International Conference on Acoustics, Speech and Signal Processing*, I, 14–17, Toulouse, France.
31. Gopalakrishnan, G., S. V. Bharath Kumar, R. Mullick, A. Narayanan and S. Suryanarayanan (2006). A Framework for Parameter Optimization in Mutual Information (MI)-based Registration Algorithms. In *Proceedings of the 2006 SPIE Medical Imaging*, 6144, 880–887, San Diego, California, USA.
32. Bharath Kumar, S. V., R. Mullick and U. Patil (2005). Textural Content in 3T MR: An Image-Based Marker for Alzheimer’s Disease. In *Proceedings of the 2005 SPIE Medical Imaging*, 5747, 1366–1376, San Diego, California, USA.
33. Bharath Kumar, S. V. and S. Umesh (2004). Non-Uniform Speaker Normalization Using Frequency-Dependent Scaling Function. In *Proceedings of the 2004 International Conference on Signal Processing and Communications*, 305–309, Bangalore, India.
34. Bharath Kumar, S. V. and S. Ramaswamy (2004). A Texture Analysis Approach for Automatic Flaw Detection in Pipelines. In *Proceedings of the 2004 International Conference on Signal Processing and Communications*, 320–323, Bangalore, India.
35. Bharath Kumar, S. V., S. Mukhopadhyay and V. Nandedkar (2004). A Novel Progressive Thick Slab Paradigm for Volumetric Medical Image Compression. In *Proceedings of the 2004 IEEE International Conference on Image Processing*, 3, 1899–1902, Singapore.
36. Bharath Kumar, S. V., S. Umesh and R. Sinha (2004). Non-Uniform Speaker Normalization Using Affine Transformation. In *Proceedings of 2004 IEEE International Conference on Acoustics, Speech and Signal Processing*, I, 121–124, Montréal, Canada.
37. Umesh, S., R. Sinha and S. V. Bharath Kumar (2004). An Investigation into Front-end Signal Processing for Speaker Normalization. In *Proceedings of the 2004 IEEE International Conference on Acoustics, Speech and Signal Processing*, I, 345–348, Montréal, Canada.
38. Bharath Kumar, S. V., N. Nagaraj, S. Mukhopadhyay and X. Xu (2003). Block-Based Conditional Entropy Coding for Medical Image Compression. In *Proceedings of the 2003 SPIE Medical Imaging*, 5033, 375–381, San Diego, California.
39. Umesh, S., S. V. Bharath Kumar, M. K. Vinay, R. Sharma and R. Sinha (2002). A Simple Approach to Non-Uniform Vowel Normalization. In *Proceedings of the 2002 IEEE International Conference on Acoustics, Speech and Signal Processing*, I, 517–520, Orlando, Florida, USA.

## Invited & Contributed Talks

*Gromov-Wasserstein Distances: Entropic Regularization, Duality, and Sample Complexity*

Department of Mathematics, Pennsylvania State University, January 25, 2024

Session on Empirical Measures and Smoothing Methods, CMStatistics, Berlin, Germany, December 17, 2023

Télécom Paris, Institut Polytechnique de Paris, November 30, 2023

Department of Statistics, London School of Economics and Political Science, October 13, 2023

*Spectral Regularized Kernel Two-Sample Tests*

Department of Mathematics, Applied Mathematics & Statistics, Case Western Reserve University, April 19, 2024

Department of Statistics & Data Science, Cornell University, March 27, 2024

Session on Advances in Kernel Methods and Gaussian Processes, CMStatistics, Berlin, Germany, December 16, 2023

Oberseminar, Faculty of Mathematics, University of Bayreuth, Germany, November 22, 2023

Statistics and Machine Learning Seminar, Department of Statistics, Carnegie Mellon University, November 9, 2023

Pattern Theory Group Seminar, Department of Applied Mathematics, Brown University, November 1, 2023

Gatsby Unit for Computational Neuroscience, University College London, UK, October 9, 2023

Session on Statistical Learning and Inference Using Kernel, Distance, and Rank, ICOSA Applied Statistics Symposium, Michigan, June 13, 2023

Department of Mathematics, State University of New York, Albany, April 3, 2023

Session on Advances in Statistical Learning Theory, IISA Conference, Bengaluru, India, December 27, 2022

Workshop on Measure-theoretic Approaches and Optimal Transportation in Statistics, November 24, 2022

*Regularized Stein Variational Gradient Flow*

Workshop on Variational Methods for Evolution, Mathematisches Forschungsinstitut Oberwolfach, Germany, December 6, 2023

Workshop on Next Generation Kernel Methods, University of New Castle Upon Tyne, UK, October 19, 2023

MaD Seminar, New York University, November 17, 2022

*Kernel Measures of Dependence and Conditional Dependence*

The 34th New England Statistics Symposium, Providence, RI, October 2, 2021

*Robust Persistence Diagrams Using Reproducing Kernels*

Fourth International Conference on Econometrics and Statistics, June 25, 2021

SIAM Conference on Computational Science and Engineering, March 4, 2021

*Johnson & Lindenstrauss Meet Hilbert at a Kernel*

Machine Learning and Dynamical Systems Seminar, Alan Turing Institute, October 26, 2023

Department of Computing, Imperial College London, October 12, 2023

International Conference on Analysis, Inverse Problems and Applications, July 18, 2022

Fifth International Conference on Econometrics and Statistics, June 5, 2022

IBM T. J. Watson Research Center, New York, July 15, 2021

52èmes Journées de Statistique de la Société Française de Statistique, Semi-Plenary Session, June 8, 2021

Statistics Seminar, CREST-CMAP, University of Paris-Saclay, April 19, 2021

*Gain with No Pain: Efficient Kernel PCA by Nyström Sampling*

Third International Conference on Econometrics and Statistics, Taichung, June 25, 2019

Approximation Theory 16, Nashville, TN, May 20, 2019



The 33rd New England Statistics Symposium, Hartford, CT, May 17, 2019

*Distribution Regression: Computational vs. Statistical Trade-off*

Department of Mathematics, Pennsylvania State University, University Park, September 30, 2019

Third International Conference on Mathematics of Data Science, Hong Kong, June 21, 2019

Inverse Problems and Machine Learning Workshop, University of Montréal, May 29, 2019

Rao Prize Conference, Pennsylvania State University, May 6, 2019

Functional Inference and Machine Intelligence Workshop, The Institute of Statistical Mathematics, Tokyo, March 28, 2019

*Minimax Estimation of Quadratic Fourier Functionals*

Data, Learning and Inference (DALI) Workshop, George, January 5, 2019

*Measures of (In)dependence Using Positive Definite Kernels*

Theoretical Statistics and Mathematics Unit, Indian Statistical Institute, Bangalore, August 24, 2018

Recent Developments in Dependence Metrics and their Applications, 4th ISNPS Conference, June 13, 2018

*Approximate Kernel PCA: Computational vs. Statistical Trade-off*

Department of Mathematics, Indian Institute of Technology, New Delhi, July 28, 2022

Department of Mathematics, State University of New York, Albany, October 12, 2020

Stochastic Seminar, Department of Mathematics, Georgia Tech, October 8, 2020

Department of Statistics, University of Georgia, September 24, 2020

International Conference on Statistical Distributions and Applications, Grand Rapids, MI, October 12, 2019

Department of Industrial and Manufacturing Engineering, Pennsylvania State University, University Park, October 10, 2019

Department of Statistics, University of Kentucky, Lexington, September 20, 2019

Microsoft Research, Bangalore, August 30, 2018

Department of Computer Science and Automation, Indian Institute of Science, Bangalore, August 21, 2018

IBM India Research Lab, Bangalore, August 14, 2018

9th International Purdue Symposium on Statistics, June 8, 2018

50èmes Journées de Statistique, Semi-Plenary Session, Paris-Saclay, May 29, 2018

Functional Inference and Machine Intelligence Workshop, The Institute of Statistical Mathematics, Tokyo, February 20, 2018

Inverse Problems and Machine Learning Workshop, Caltech, February 11, 2018

*Statistical Consistency of Kernel PCA with Random Features*

Session on Nonparametrics, 55th Annual Allerton Conference on Communication, Control and Computing, October 6, 2017

Center for Applied Mathematics, École Polytechnique, July 6, 2017

Department of Mathematics, University of Stuttgart, June 29, 2017

*Shrinkage Estimation in Reproducing Kernel Hilbert Spaces*

BLISS Seminar, Department of EECS, University of California, Berkeley, November 15, 2017

Center for Applied Mathematics, École Polytechnique, July 4, 2017

Machine Learning Seminar, Carnegie Mellon University, February 7, 2017

*Random Fourier Features and Beyond*

New Directions for Learning with Kernels and Gaussian Processes, Dagstuhl Seminar 16481, December 1, 2016

*On the Kernel Choice in RKHS-based Two Sample Tests*

Third Conference of International Society for Nonparametric Statistics, Avignon, June 12, 2016

*Minimax Estimation of Kernel Mean Embeddings*

Gatsby Unit, University College London, May 4, 2016

Department of Statistics, University of Oxford, May 3, 2016

*Density Estimation in Infinite Dimensional Exponential Families*

Department of Statistics, George Mason University, March 23, 2018

Flexible Modeling Workshop, The 10th ICSA International Conference, December 22, 2016

Department of Statistics, London School of Economics & Political Science, April 29, 2016

Department of Mathematics, University of Delaware, April 6, 2016

Department of Operations Research and Financial Engineering, Princeton University, April 4, 2016

Department of Statistics, Pennsylvania State University, September 18, 2015

Department of Statistics, University of Wisconsin-Madison, April 29, 2015

Data, Learning and Inference (DALI) Workshop, La Palma, April 12, 2015

Modern Non-parametrics Workshop, NIPS 2014, December 13, 2014

Department of Statistical Science, University College London, June 19, 2014

Department of Engineering, University of Cambridge, May 14, 2014

Department of Statistics, University of Oxford, May 9, 2014

Department of Statistics, Columbia University, May 2, 2014

Sixth International Conference of the ERCIM WG on Computational and Methodological Statistics (ERCIM 2013), December 14, 2013

Max Planck Institute for Intelligent Systems, October 9, 2013

*Kernel Mean Shrinkage Estimators*

Department of Statistics, University of Wisconsin-Madison, April 29, 2015

*RKHS Induced Infinite Dimensional Exponential Families: Density Estimation and Beyond*

Weierstrass Institute for Applied Analysis and Stochastics, July 10, 2013

*Mixture Sieve Density Estimation and Hilbert Space Embedding of Measures*

School of Computing, National University of Singapore, October 31, 2011

National ICT Australia, Canberra, October 27, 2011

Faculty of Mathematical Sciences, Queensland University of Technology, Brisbane, Australia, October 20, 2011

*Hilbert Space Embeddings and Metrics on Probability Measures*

Statistische Woche 2013 (German Statistical Week), Freie Universität Berlin, September 20, 2013

School of Engineering, Computing and Mathematics, University of Exeter, December 10, 2012

Eighth World Congress in Probability and Statistics, Istanbul, Turkey, July 9, 2012

Department of Pure Mathematics and Mathematical Statistics, University of Cambridge, UK, March 9, 2012

Department of Computer Science and Engineering, Pennsylvania State University, State College, February 24, 2012

Department of Statistics, Pennsylvania State University, State College, February 23, 2012

Department of Mathematics, London School of Economics and Political Science, UK, February 9, 2012

Toyota Technological Institute, Chicago, Illinois, March 3, 2011

Department of Statistics, University of Warwick, Coventry, UK, February 25, 2011

Gatsby Computational Neuroscience Unit, University College London, June 8, 2010

Machine Learning Group, University of Tokyo, Japan, November 18, 2009

Workshop on Machine Learning Methods in Statistical Science, The Institute of Statistical Mathematics, Tokyo, October 23, 2009

Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, India, December 16, 2008

*Non-Parametric Estimation of Integral Probability Metrics*

IEEE International Symposium on Information Theory, Austin, Texas, June 15, 2010

*On the Relation Between Universality, Characteristic Kernels and RKHS Embedding of Measures*

Thirteenth International Conference on Artificial Intelligence and Statistics, Sardinia, Italy, May 15, 2010

*On the Convergence of the Concave-Convex Procedure*

Workshop on Optimization for Machine Learning, Whistler, Canada, December 12, 2009

*Kernel Choice and Classifiability for RKHS Embeddings of Probability Distributions*

Twenty-Third Annual Conference on Neural Information Processing Systems, Vancouver, Canada, December 9, 2009

*The Sparse Eigenvalue Problem*

Department of Computer Science and Automation, Indian Institute of Science, Bangalore, India, December 10, 2008

*Injective Hilbert Space Embeddings of Probability Measures*

Twenty-First Annual Conference on Learning Theory, Helsinki, Finland, July 10, 2008

Max Planck Institute for Biological Cybernetics, Tübingen, Germany, July 1, 2008

*Metric Embedding for Kernel Classification Rules*

Twenty-Fifth International Conference on Machine Learning, Helsinki, Finland, July 8, 2008

*Finding Musically Meaningful Words Using Sparse CCA*

Music, Brain and Cognition Workshop, Whistler, Canada, December 7, 2007

*Sparse Eigen Methods by D.C. Programming*

Max Planck Institute for Biological Cybernetics, Tübingen, Germany, July 11, 2007

Twenty-Fourth International Conference on Machine Learning, Corvallis, Oregon, June 23, 2007

## Conference/Workshop/Session Organization

Co-organizer, PSU-Purdue-UMD Joint Seminar on Mathematical Data Science, September 2023–present

Organizer, Invited Session on *Recent Advances in Machine Learning* at EcoSta Conference, Kyoto, Japan, June 5, 2022

Organizer, Invited Session on *Nonparametric Methods and Learning Theory* at IISA Conference, Mumbai, India, December 30, 2019

Organizer, Invited Session on *Approximation, Learning and Inference with Positive-Definite Kernels* at ISNPS Conference, Salerno, Italy, June 15, 2018

*Co-organizer, NIPS Workshop on Learning on Distributions, Functions, Graphs and Groups, Long Beach, California, USA, December 8, 2017*

*Co-organizer, NIPS Workshop on Adaptive and Scalable Nonparametric Methods in Machine Learning, Barcelona, Spain, December 10, 2016*

*Co-organizer, ICML Workshop on RKHS and Kernel-based Methods: Theoretical Topics and Recent Advances, Edinburgh, UK, July 1, 2012*

## Grants

Reproducing Kernel Hilbert Space Embedding of Measures: Theory and Applications to Statistical Learning. NSF DMS 1713011. \$178,251 2017-2020

Statistical Learning, Inference and Approximation with Reproducing Kernels. NSF DMS CAREER 1945396. \$400,000 2020-2025

Collaborative Research: Synergies between Stein's Identities and Reproducing Kernels: Modern Tools for Nonparametric Statistics. NSF DMS 2413425. \$179,999 2024-2027

## Professional Activities

Associate Editor, Statistics and Probability Letters (2024–present)

Action Editor, Journal of Machine Learning Research (2021–present)

Associate Editor, Mathematical Foundations of Computing (2020–present)

Editorial Board, Journal of Machine Learning Research (2015–2021)

Scientific Committee, Workshop on Lifting Inference with Kernel Embeddings (2022, 2023)

Senior Program Committee Member, International Conference on Machine Learning (2018)

Senior Program Committee Member, Neural Information Processing Systems (2013, 2015–2019, 2024)

Senior Program Committee Member, Artificial Intelligence and Statistics (2016–2023)

Senior Program Committee Member, Conference on Learning Theory (2021–2024)

Senior Program Committee Member, Algorithmic Learning Theory (2020, 2024)

*Journal Reviewing:* Annals of Statistics, Annals of the Institute of Statistical Mathematics, Analysis Mathematica, Applied and Computational Harmonic Analysis, Bernoulli, Biometrika, Constructive Approximation, Electronic Journal of Statistics, Foundations of Computational Mathematics, IEEE Transactions on Information Theory, IEEE Transactions on Pattern Recognition and Machine Intelligence, Memoirs of the American Mathematical Society, IEEE Transactions on Signal Processing, Journal of Machine Learning Research, Journal of Royal Statistical Society (Series B), Machine Learning, Neural Computation, Scandinavian Journal of Statistics, Signal Processing Magazine, Statistics and Computing, Statistical Science

*Conference Reviewing:* International Conference on Machine Learning (ICML), International Conference on Artificial Intelligence and Statistics (AISTATS), Advances in Neural Information Processing Systems (NIPS), Conference on Learning Theory (COLT), International Symposium on Information Theory (ISIT), International Conference on Acoustics, Speech and Signal Processing (ICASSP), International Joint Conference on Artificial Intelligence (IJCAI)

NSF DMS CAREER Statistics Panelist (2023)

NSF DMS Statistics Panelist (2019, 2021)

## Teaching

Instructor, Research School: Statistical and Geometric Divergences for Machine Learning, University of Rennes 2, Rennes <i>Kernel Based Distances and Applications in Statistics and Machine Learning (3 hours)</i>	06/2022
Instructor, Data Science Summer School, École Polytechnique, Paris <i>Learning with Positive Definite Kernels: Theory and Applications (3 hours)</i>	06/2019
Instructor, Machine Learning Summer School, MPI for Intelligent Systems, Tübingen <i>Introduction to Kernel Methods (3 hours)</i>	06/2017
Instructor, Pennsylvania State University STAT 508 <i>Applied Data Mining and Statistical Learning</i> STAT 590 <i>Colloquium</i> STAT 508 <i>Applied Data Mining and Statistical Learning</i> STAT 597 <i>Nonparametric Methods and Learning Theory</i> STAT 515 <i>Stochastic Processes and Monte-Carlo Methods</i> STAT 508 <i>Applied Data Mining and Statistical Learning</i> MATH/STAT 415 <i>Mathematical Statistics</i> STAT 515 <i>Stochastic Processes and Monte-Carlo Methods</i> MATH/STAT 415 <i>Mathematical Statistics</i> STAT 597 <i>Nonparametric Methods and Learning Theory</i> STAT 515 <i>Stochastic Processes and Monte-Carlo Methods</i> MATH/STAT 415 <i>Mathematical Statistics</i> STAT 514 <i>Theory of Statistics II</i> STAT 515 <i>Stochastic Processes and Monte-Carlo Methods</i> MATH/STAT 415 <i>Mathematical Statistics (2 sections)</i> STAT 597 <i>Nonparametric Methods and Learning Theory</i> MATH/STAT 415 <i>Mathematical Statistics</i> STAT 514 <i>Theory of Statistics II</i> STAT 514 <i>Theory of Statistics II</i> MATH/STAT 415 <i>Mathematical Statistics (2 sections)</i> STAT 514 <i>Theory of Statistics II</i> MATH/STAT 415 <i>Mathematical Statistics</i> MATH/STAT 415 <i>Mathematical Statistics</i> STAT 401 <i>Experimental Methods</i>	01-05/2024 01-05/2024 01-05/2023 08-12/2022 01-05/2022 01-05/2022 08-12/2021 01-05/2021 01-05/2021 08-12/2020 01-05/2020 08-12/2019 08-12/2019 01-05/2019 01-05/2019 01-05/2018 01-05/2018 08-12/2017 08-12/2016 08-12/2016 08-12/2015 08-12/2015 01-05/2015 01-05/2015
Supervisor (King's College), University of Cambridge 1B <i>Statistics</i>	01-06/2013
Lecturer, University of Cambridge IIC <i>Statistical Modelling</i>	01-03/2013
Co-Instructor, University College London COMPG13 <i>Advanced Topics in Machine Learning</i> <i>Adaptive Modelling of Complex Data</i>	01-04/2012
Teaching Assistant, University of California San Diego ECE 273 <i>Convex Optimization and Applications</i>	04-06/2010
Instructor, Edison Engineer Development Program, General Electric Global Research <i>Signals &amp; Systems</i>	2004-2005
Teaching Assistant, Indian Institute of Technology Kanpur EE 380 <i>Electrical Engineering Lab</i> EE 370 <i>Digital Electronics and Microprocessor Technology</i>	08-12/2001 01-05/2001

## Advising

### Postdoctoral Mentor:

Sakshi Arya (08/2021–07/2023) [*Tenure-Track Assistant Professor, Department of Mathematics, Applied Mathematics, and Statistics, Case Western Reserve University*]

### PhD Thesis Advisor:

Nicholas Sterge (08/2016–10/2021) [*Flow Traders, New York*]

Siddharth Viswanath (08/2018–06/2023) [*SEW Visiting Assistant Professor, Department of Mathematics, UC San Diego*]

Omar Hagrass (08/2019–05/2024) [*Postdoctoral Research Associate, Department of Operations Research and Financial Engineering, Princeton University*]

Sowmya Mukherjee (06/2022–present)

Aratrika Mustafi (06/2022–present)

Nathan Weaver (08/2024–present)

### PhD Thesis Co-advisor:

Nikolas Siapoutis (08/2018–05/2022) [*Teaching Assistant Professor, Department of Statistics, University of Pittsburgh*]

Tianhong Sheng (08/2018–07/2022) [*Data Scientist, Pinterest, San Francisco*]

### MS Thesis Advisor:

Benjamin Straub (08/2017–05/2018) [*Principal Programmer, GSK, Philadelphia*]

Aniruddha Rajendra Rao (08/2017–06/2019) [*Machine Learning Researcher, Hitachi America, Santa Clara*],

Nikolas Siapoutis (08/2018–06/2019) [*Teaching Assistant Professor, Department of Statistics, University of Pittsburgh*]

### PhD Academic Advisor:

Jordan Awan, Aniruddha Rajendra Rao, Roopali Singh and Alex Zhao, Department of Statistics, Pennsylvania State University 08/2016–05/2018

### Undergraduate Honor's Thesis Advisor:

Zhenyuan Yuan (12/2016–05/2018) [*PhD Candidate, Department of EECS, Pennsylvania State University*]

## PhD Committees

### Chair

Elena Hadjicosta, Department of Statistics, Pennsylvania State University 2017–19

### Member

Jonathan Taylor Jenkins, Department of Mathematics, Pennsylvania State University 06/2024–present

Chaegeun Song, Department of Statistics, Pennsylvania State University 07/2023–present

Yin Tang, Department of Statistics, Pennsylvania State University 04/2023–present

Anping Pan, Department of Mathematics, Pennsylvania State University 03/2023–present

Wilson Peoples, Department of Mathematics, Pennsylvania State University 01/2022–present

Bokgyeong Kang, Department of Statistics, Pennsylvania State University 2021–23

Seong-ho Lee, Department of Statistics, Pennsylvania State University 2021–23

Mihir Mehta, Department of Industrial Engineering, Pennsylvania State University 2021–23

Huy Dang, Department of Statistics, Pennsylvania State University 2021–23

Jeremy Seeman, Department of Statistics, Pennsylvania State University 2021–23

Stephen White, Department of Mathematics, Pennsylvania State University	2021–23
Harris Quach, Department of Statistics, Pennsylvania State University	2021–22
Ilias Moysidis, Department of Statistics, Pennsylvania State University	2019–21
Faheem Gilani, Department of Mathematics, Pennsylvania State University	2019–21
Zhanrui Cai, Department of Statistics, Pennsylvania State University	2019–21
Peng Cheng, Department of Industrial and Manufacturing Engineering, Pennsylvania State University	2018–20
Jordan Awan, Department of Statistics, Pennsylvania State University	2018–20
Kyongwon Kim, Department of Statistics, Pennsylvania State University	2018–20
Patrick Godwin, Department of Physics, Pennsylvania State University	2017–20
Cheng-Bang Chen, Department of Industrial and Manufacturing Engineering, Pennsylvania State University	2017–19
Sanghack Lee, Information Sciences and Technology, Pennsylvania State University	2016–18
Junli Lin, Department of Statistics, Pennsylvania State University	2017
Hyunphil Choi, Department of Statistics, Pennsylvania State University	2016–17
Zachary Jones, Department of Political Science, Pennsylvania State University	2016–17
Adrian Maler, Department of Mathematics, Pennsylvania State University	2015

#### *External Examiner*

Tamim El Ahmad, LTCI, Télécom Paris, Institut Polytechnique de Paris, France	12/2022–present
Wojciech Reise, Université Paris-Saclay and INRIA, France	2023
Luc Brogat-Motte, Télécom Paris, Institut Polytechnique de Paris, France	2023
Shashank Singh, Machine Learning Department, Carnegie Mellon University, USA	2018–19
Damien Garreau, École Normale Supérieure, France	2017
Ülker Okur, Department of Mathematics, University of Stuttgart, Germany	2016
Aurélien Guetsop Nangue, Department of Statistics, University of Montréal, Canada	2016
K. Balasubramanian, Department of Electronics and Communication Engineering, Amrita School of Engineering, India	2016

## Department/University Activities

<i>Member</i> , Faculty Hiring Committee, Pennsylvania State University	2024–25
<i>Chair</i> , Graduate Admissions Committee, Pennsylvania State University	2022–24
<i>Chair</i> , Graduate Curriculum Committee, Pennsylvania State University	2021–24
<i>Member</i> , Data Science Working Group, Pennsylvania State University	2021–present
<i>Member</i> , Eberly Fellow Hiring Committee, Pennsylvania State University	2021
<i>Sub-committee Chair</i> , Strategic Planning Committee, Pennsylvania State University	2020–21
<i>Chair</i> , Ph.D. Qualifying Exam Committee, Pennsylvania State University	2020–21
<i>Member</i> , Graduate Admission Committee, Pennsylvania State University	2019–22
<i>Committee Member</i> , 2019 Rao Prize Conference, Pennsylvania State University	2018–19
<i>Member</i> , Faculty Hiring Committee, Pennsylvania State University	2018–19
<i>Committee Member</i> , 2018 Chemerda Lecture, Pennsylvania State University	2017–18
<i>Committee Member</i> , 2017 Marker Lecture, Pennsylvania State University	2017
<i>Committee Member</i> , 2017 Rao Prize Conference, Pennsylvania State University	2017
<i>Interviewer</i> , Millenium Scholars Program, Pennsylvania State University	2017

<i>Committee Member, 2017 Clifford Clogg Lecture, Pennsylvania State University</i>	2017
<i>Committee Member, 2016 Clifford Clogg Lecture, Pennsylvania State University</i>	2016
<i>Committee Member, 2016 Marker Lecture, Pennsylvania State University</i>	2016
<i>Co-organizer, Statistics Colloquium, Pennsylvania State University</i>	2015–16
<i>Member, Ph.D. Qualifying Exam Committee, Pennsylvania State University</i>	2014–15