

# Anima Anandkumar

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Computer & Mathematical Sciences,  
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## Current Research Interests

Large-scale machine learning and high-dimensional statistics with a focus on non-convex optimization, spectral methods and probabilistic models.

## Current Appointments

**Bren Professor** *Since July 2017.*  
Computing and Mathematical Sciences Dept., California Institute of Technology, Pasadena, CA, USA.

**Principal Scientist**, Amazon Web Services (AWS), Palo Alto, CA, USA. *since Oct. 2016.*

**Associate Professor** *Aug. 2016-June 2017.*  
Electrical Engr & Computer Science, University of California, Irvine, CA, USA.

## Education

**Doctor of Philosophy** in Electrical Engineering with minor in Applied Mathematics *July 2009*  
advised by Prof. Lang Tong, Electrical & Computer Engr, Cornell University, Ithaca, NY, USA.

**Bachelor of Technology** in Electrical Engineering with minor in Theoretical Comp. Science *May 2004*  
Indian Institute of Technology Madras, Department of Electrical Engineering, Chennai, India.

## Awards and Honors

1. **Google Faculty Research Award 2015.**
2. **Air Force Office of Sponsored Research (AFOSR) Young Investigator Award (YIP) 2015.**
3. **MLConf Industry Impact Student Award 2015 for Furong Huang (Advisee), sponsored by Google.**
4. **UCI Early Career Research Award 2015.**
5. **Alfred P. Sloan Research Fellowship 2014.**
6. **Microsoft Faculty Fellowship 2013.**
7. **ARO Young Investigator Award (YIP) 2013.**
8. **NSF CAREER Award 2013.**
9. **ACM SIGMETRICS 2011 Best Paper Award.**
10. **Best Thesis Award 2009** by ACM SIGMETRICS Society.
11. **IEEE Signal Processing Society Young Author Best Paper Award 2008.**
12. **Fran Allen IBM PhD Fellowship 2008-09.**

## Previous Appointments

**Assistant Professor**, EECS Dept., University of California, Irvine, CA, USA. *Aug. 2010-2016*

**Visiting Researcher** at Microsoft Research New England, Cambridge, MA, USA. *April-Dec. 2012*

**Post-doctoral Associate** at the Laboratory of Information & Decision Systems *July 2009-July 2010*  
with Prof. Alan Willsky, MIT, Cambridge, MA, USA.

## Principal Research: Machine Learning

### Preprints (Available on Webpage)

- [1] Furong Huang and Animashree Anandkumar. Unsupervised learning of word-sequence representations from scratch via convolutional tensor decomposition. *arXiv preprint arXiv:1606.03153*, 2016.
- [2] F. Arabshahi and A. Anandkumar. Beyond LDA: A Unified Framework for Learning Latent Normalized Infinitely Divisible Topic Models through Spectral Methods. *arXiv preprint arXiv:1603.00954*, 2016.
- [3] Furong Huang, Animashree Anandkumar, Christian Borgs, Jennifer Chayes, Ernest Fraenkel, Michael Hawrylycz, Ed Lein, Alessandro Ingrosso, and Srinivas Turaga. Discovering neuronal cell types and their gene expression profiles using a spatial point process mixture model. *arXiv preprint arXiv:1602.01889*, 2016.
- [4] H. Sedghi and A. Anandkumar. Training input-output recurrent neural networks through spectral methods. *arXiv preprint arXiv:1603.00954*, 2016.
- [5] A. Anandkumar and H. Sedghi. Learning mixed membership community models in social tagging networks through tensor methods. *ArXiv 1503.04567*, 2015.
- [6] F. Huang, U.N. Niranjan, J. Perros, R. Chen, J. Sun, and A. Anandkumar. Scalable Latent Tree Model and its Application to Health Analytics. *Preprint*, Feb. 2015.

### Journal Publications

- [7] M. Janzamin, H. Sedghi, and A. Anandkumar. Beating the perils of non-convexity: Guaranteed training of neural networks using tensor methods. *arXiv preprint arXiv:1506.08473*, 2015.
- [8] A. Anandkumar, R. Ge, and M. Janzamin. Analyzing tensor power method dynamics: Applications to learning overcomplete latent variable models. *Accepted to JMLR*, 2015.
- [9] F. Huang, U.N. Niranjan, M. Hakeem, and A. Anandkumar. Online tensor methods for learning latent variable models. *Journal of Machine Learning Research*, 16:2797–2835, 2015.
- [10] A. Anandkumar, D. Hsu, M. Janzamin, and S. M. Kakade. When are Overcomplete Topic Models Identifiable? Uniqueness of Tensor Tucker Decompositions with Structured Sparsity. *Journal of Machine Learning Research*, 16:2643–2694, 2015.
- [11] A. Anandkumar, R. Ge, D. Hsu, S. M. Kakade, and M. Telgarsky. Tensor Methods for Learning Latent Variable Models. *J. of Machine Learning Research*, 15:2773–2832, 2014.
- [12] M. Janzamin and A. Anandkumar. High-Dimensional Covariance Decomposition into Sparse Markov and Independence Domains. *J. of Machine Learning Research*, 15:1549–1591, 2014.
- [13] A. Anandkumar, R. Ge, D. Hsu, and S. M. Kakade. A Tensor Approach to Learning Mixed Membership Community Models. *J. of Machine Learning Research*, (15):2239–2312, June 2014.
- [14] A. Anandkumar, D. P Foster, D. Hsu, S. M Kakade, and Y. Liu. A spectral algorithm for latent dirichlet allocation. *Algorithmica*, 72(1):193–214.
- [15] A. Anandkumar and R. Valluvan. Learning Loopy Graphical Models with Latent Variables: Efficient Methods and Guarantees. *Annals of Statistics*, 41(2):401–435, 2013.
- [16] A. Anandkumar, V. Y. F. Tan, F. Huang, and A. S. Willsky. High-dimensional structure learning of Ising models: local separation criterion. *The Annals of Statistics*, 40(3):1346–1375, 2012.

- [17] A. Anandkumar, V. Y. F. Tan, F. Huang, and A. S. Willsky. High-Dimensional Gaussian Graphical Model Selection: Walk-Summability and Local Separation Criterion. *J. Machine Learning Research*, 13:2293–2337, Aug. 2012.
- [18] A. Anandkumar, A. Hassidim, and J. Kelner. Topology discovery of sparse random graphs with few participants. *J. of Random Structures and Algorithms*, 43, June 2013.
- [19] Y. Liu, V. Chandrasekaran, A. Anandkumar, and A. Willsky. Feedback Message Passing for Inference in Gaussian Graphical Models. *IEEE Tran. on Signal Processing*, 60(8):4135–4150, Aug. 2012.
- [20] M.J. Choi, V.Y.F. Tan, A. Anandkumar, and A. Willsky. Learning latent tree graphical models. *J. of Machine Learning Research*, 12:1771–1812, May 2011.
- [21] V.Y.F. Tan, A. Anandkumar, and A. Willsky. Learning Markov forest models: analysis of error rates. *J. of Machine Learning Research*, 12:1617–1653, May 2011.
- [22] V.Y.F. Tan, A. Anandkumar, and A. Willsky. A large-deviation analysis for the maximum likelihood learning of tree structures. *IEEE Tran. on Information Theory*, 57(3):1714–1735, March 2011.
- [23] V.Y.F. Tan, A. Anandkumar, and A. Willsky. Learning Gaussian tree models: analysis of error exponents and extremal structures. *IEEE Tran. on Signal Processing*, 58(5):2701–2714, May 2010.

### Conference Publications (Limited List)

- [24] Yining Wang and Animashree Anandkumar. Online and differentially-private tensor decomposition. *arXiv preprint arXiv:1606.06237*, 2016.
- [25] Yang Shi, UN Niranjan, Animashree Anandkumar, and Cris Cecka. Tensor contractions with extended blas kernels on cpu and gpu. *arXiv preprint arXiv:1606.05696*, 2016.
- [26] K. Azizzadenesheli, A. Lazaric, and A. Anandkumar. Reinforcement learning of pomdps using spectral methods. In *Proc. of COLT*, 2016.
- [27] A. Anandkumar and R. Ge. Efficient approaches for escaping higher order saddle points in non-convex optimization. In *Proc. of COLT*, 2016.
- [28] A. Anandkumar, P. Jain, Y. Shi, and U. N. Niranjan. Tensor vs matrix methods: Robust tensor decomposition under block sparse perturbations. In *Proc. of AISTATS*, May 2016.
- [29] F. Huang and A. Anandkumar. Convolutional dictionary learning through tensor factorization. In *Special Proceedings of Journal of Machine Learning Research (JMLR)*, volume 44, pages 1–10, 2015.
- [30] H. Sedghi, M. Janzamin, U. N. Niranjan, and A. Anandkumar. Performance analysis of feast: Feature extraction using score function tensors. In *Special Proceedings of Journal of Machine Learning Research (JMLR)*, volume 44, 2015.
- [31] H. Sedghi and A. Anandkumar. Provable Tensor Methods for Learning Mixtures of Generalized Linear Models. In *Proc. of AISTATS*, May 2016.
- [32] Y. Wang, H. Tung, A. Smola, and A. Anandkumar. Fast and guaranteed tensor decomposition via sketching. In *Proc. of Neural Information Processing (NIPS)*, 2015.
- [33] F. Arabshahi, F. Huang, A. Anandkumar, and C. T Butts. Modeling dynamic social interactions via conditional latent tree models. In *Proc. of ICDM*, Nov. 2015.
- [34] T. Nimmagadda and A. Anandkumar. Multi-Object Classification and Unsupervised Scene Understanding Using Deep Learning Features and Latent Tree Probabilistic Models. In *SUN workshop, Proc. of CVPR*, 2015.

- [35] A. Anandkumar, R. Ge, and M. Janzamin. Learning Overcomplete Latent Variable Models through Tensor Methods. In *Conf. on Learning Theory*, July 2015.
- [36] P. Netrapalli, Niranjan U. N., S. Sanghavi, A. Anandkumar, and P. Jain. Provable Non-convex Robust PCA. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2014.
- [37] H. Sedghi, A. Anandkumar, and E. Jonckheere. Guarantees for Stochastic ADMM in High Dimensions. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2014.
- [38] H. Sedghi and A. Anandkumar. Provable methods for training neural networks with sparse connectivity. In *NIPS Deep Learning Workshop*, 2014.
- [39] L. Song, A. Anandkumar, B. Dai, and B. Xie. Nonparametric Estimation of Multi-View Latent Variable Models. In *Proc. of ICML*, June 2014.
- [40] A. Agarwal, A. Anandkumar, P. Jain, P. Netrapalli, and R. Tandon. Learning Sparsely Used Overcomplete Dictionaries. In *Conference on Learning Theory (COLT)*, June 2014.
- [41] A. Anandkumar, D. Hsu, M. Janzamin, and S. M. Kakade. When are Overcomplete Topic Models Identifiable? Uniqueness of Tensor Tucker Decompositions with Structured Sparsity. In *Neural Information Processing (NIPS)*, Dec. 2013.
- [42] A. Anandkumar, R. Ge, D. Hsu, and S. M. Kakade. A Tensor Spectral Approach to Learning Mixed Membership Community Models. In *Conference on Learning Theory (COLT)*, June 2013.
- [43] A. Anandkumar, D. Hsu, A. Javanmard, and S. M. Kakade. Learning Bayesian Networks with Latent Variables. In *Proc. of Intl. Conf. on Machine Learning*, June 2013.
- [44] A. Anandkumar and R. Valluvan. Learning Loopy Graphical Models with Latent Variables: Efficient Methods and Guarantees. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2012.
- [45] A. Anandkumar, D. P. Foster, D. Hsu, S. M. Kakade, and Y. K. Liu. A Spectral Algorithm for Latent Dirichlet Allocation. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2012.
- [46] A. Anandkumar, D. Hsu, F. Huang, and S.M. Kakade. Learning Mixtures of Tree Graphical Models. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2012.
- [47] M. Janzamin and A. Anandkumar. High-Dimensional Covariance Decomposition into Sparse Markov and Independence Domains. In *Proc. of International Conf. on Machine Learning*, June 2012.
- [48] A. Anandkumar, D. Hsu, and S.M. Kakade. A Method of Moments for Mixture Models and Hidden Markov Models. In *Proc. of Conf. on Learning Theory*, June 2012.
- [49] A. Anandkumar, V. Y. F. Tan, and A. S. Willsky. High-Dimensional Graphical Model Selection: Tractable Graph Families and Necessary Conditions. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2011. *Oral Presentation, AR 1%*.
- [50] A. Anandkumar, K. Chaudhuri, D. Hsu, S.M. Kakade, L. Song, and T. Zhang. Spectral Methods for Learning Multivariate Latent Tree Structure. In *Proc. of Neural Information Processing (NIPS)*, Dec. 2011.
- [51] A. Anandkumar, A. Hassidim, and J. Kelner. Topology Discovery of Sparse Random Graphs With Few Participants. In *Proc. of ACM SIGMETRICS*, June 2011. **Winner of Best Paper Award**.
- [52] M. A. Khajehnejad, J. Yoo, A. Anandkumar, and B. Hassibi. Summary Based Structures with Improved Sublinear Recovery for Compressed Sensing. In *Proc. of IEEE ISIT*, July 2011.

## PhD Theses Advised/Co-advised

- [53] Furong Huang. Discovery of latent factors in high-dimensional data using tensor methods. 2016.
- [54] Majid Janzamin. Non-convex optimization in machine learning: Provable guarantees using tensor methods. 2016.
- [55] Hanie Sedghi. Stochastic optimization in high dimension. 2016.

## Open source code repositories

- [56] Spectral methods for training latent Dirichlet allocation topic models on Apache Spark. <https://github.com/FurongHuang/SpectralLDA-TensorSpark>.
- [57] Learning mixed membership community models. <https://github.com/FurongHuang/OnlineTensorCommunity>.
- [58] Fast tensor decomposition algorithms. <https://bitbucket.org/megaDataLab/tensormethodsforml/overview>.
- [59] Stochastic ADMM in High Dimensions. <https://bitbucket.org/megaDataLab/reason2.git>.
- [60] Robust PCA. <https://bitbucket.org/megaDataLab/ncrpca.git>.
- [61] Robust tensor decomposition. <https://bitbucket.org/shiyangdaisy/tensor-robust-pca>.

## Other Research: Signal Processing, Networks & Info. Theory

### Journal Publications (Limited List)

- [62] Amod JG Anandkumar, Animashree Anandkumar, Sangarapillai Lambotharan, and Jonathon A Chambers. Robust rate maximization game under bounded channel uncertainty. *Vehicular Technology, IEEE Transactions on*, 60(9):4471–4486, 2011.
- [63] A. Anandkumar, J.E. Yukich, L. Tong, and A. Swami. Energy Scaling Laws for Distributed Inference in Random Networks. *IEEE J. Selec. Area Comm.*, 27(7):1203–1217, Sept. 2009.
- [64] A. Anandkumar, L. Tong, and A. Swami. Detection of Gauss-Markov Random Fields with Nearest-neighbor Dependency. *IEEE Tran. Information Theory*, 55(2):816–827, Feb. 2009.
- [65] A. Anandkumar, N. Michael, A.K. Tang, and A. Swami. Distributed algorithms for learning and cognitive medium access with logarithmic regret. *Selected Areas in Communications, IEEE Journal on*, 29(4):731–745, 2011. **Best Readings on Cognitive Radio by IEEE Comsoc society.**
- [66] A. Anandkumar, L. Tong, and A. Swami. Distributed Estimation Via Random Access. *IEEE Tran. Information Theory*, 54(7):3175–3181, July 2008.
- [67] A. Anandkumar and L. Tong. Type-Based Random Access for Distributed Detection over Multiaccess Fading Channels. *IEEE Tran. Signal Proc.*, 55(10):5032–5043, Oct. 2007. **IEEE Signal Processing Society 2008 Young Author Best Paper Award.**

### Conference Publications (Limited List)

- [68] F. Huang and A. Anandkumar. Fast, Concurrent and Distributed Load Balancing under Switching Costs and Imperfect Observations. In *Proc. of IEEE INFOCOM*, Apr. 2013.
- [69] T. He, A. Anandkumar, and D. Agrawal. Index-based sampling policies for tracking dynamic networks under sampling constraints. In *Proc. of IEEE INFOCOM*, May 2011. *AR 15.96%*.

- [70] P. Balister, B. Bollobas, A. Anandkumar, and A.S. Willsky. Energy-latency tradeoff for in-network function computation in random networks. In *Proc. of IEEE INFOCOM*, May 2011. *AR 15.96%*.
- [71] A. Anandkumar, N. Michael, and A.K. Tang. Opportunistic Spectrum Access with Multiple Users: Learning under Competition. In *Proc. of IEEE INFOCOM*, San Deigo, USA, March 2010. *AR 17%*.
- [72] A. Anandkumar, M. Wang, L. Tong, and A. Swami. Prize-Collecting Data Fusion for Cost-Performance Tradeoff in Distributed Inference. In *Proc. of IEEE INFOCOM*, Rio De Janeiro, Brazil, April 2009. *AR 20%*.
- [73] A. Anandkumar, C. Bisdikian, and D. Agrawal. Tracking in a Spaghetti Bowl: Monitoring Transactions Using Footprints. In *Proc. ACM Intl. Conf. on Measurement & Modeling of Computer Systems (Sigmetrics)*, Annapolis, Maryland, USA, June 2008. *AR 18%*.
- [74] A. Anandkumar, L. Tong, A. Swami, and A. Ephremides. Minimum Cost Data Aggregation with Localized Processing for Statistical Inference. In *Proc. of INFOCOM*, pages 780–788, Phoenix, USA, April 2008. *AR 20%*.
- [75] A. Anandkumar and L. Tong. A Large Deviation Analysis of Detection over Multi-Access Channels with Random Number of Sensors. In *Proc. of ICASSP'06*, volume IV, pages 1097–1101, Toulouse, France, May 2006. **Best Paper Award**.

### Book Chapters

- [76] A. Anandkumar, A. Ephremides, A. Swami, and L. Tong. Routing for Statistical Inference in Sensor Networks. In S. Haykin and R. Liu, editors, *Handbook on Array Processing and Sensor Networks*, chapter 23. John Wiley & Sons, 2009.

### Invention Disclosures

- [77] A. Anandkumar and D. Agrawal and C. Bisdikian and T. He, and S. Perelman. Selective Instrumentation For Distributed Applications For Transaction Monitoring. *US 8433786 B2*, April 2013.

### Teaching

Special topics in ML (2013,2015), Signals & Systems (2012-15), Large-scale ML (2014), Stat. Learning Theory (2014), Estimation Theory (2011-15), Random Processes (2010-11).

### Funding

Google faculty fellowship, AFOSR Young Investigator Award YIP, ONR (PI), Sloan fellowship, Microsoft faculty fellowship, NSF BigData (PI), ARO YIP, NSF Career (PI), NSF CCF (PI).

### Service

PC for ICML 2012-16, AISTATS 2016, NIPS 2014-16, UAI 2013-14, SIGMETRICS 2014-16. Action Editor for Journal of Machine Learning Research. Assoc. Editor for IEEE Tran. on Signal Processing (till 2014).

Organizer of the workshop on optimization and matrix methods at Fields institute (Feb. 2015), non-convex optimization at NIPS 2015 & ICML 2016, tensor methods at Dagstuhl in 2016.

Recipient of IBM grant of \$30,000 as part of Fran Allen award to mentor female students.

## **In the News**

Article on non-convex methods in **Huffington post and Forbes**. ([Link 1](#)), ([Link 2](#)).

**Quora session on machine learning**. ([Link](#))

**Interview with Amplify partner David Beyer**. ([Link](#))

**O'Reilly Data Show Podcast: tensor decomposition techniques for machine learning**. ([Link](#))

**Interview at IIT GLC alumni event on data science**. ([Link](#))

**Announcement of AFOSR YIP**, Feb. 2015. ([Link](#))

**Announcement of the Sloan fellowship**, Feb. 2014. ([Link](#))

**Announcement of Microsoft faculty award**, July 2013. ([Link 1](#)), ([Link 2](#)). ([Interview](#)).

**Article on Sizing Samples in ACM Technews and MIT news**, September 2010. ([Link 1](#)), ([Link 2](#))

**Article on Fran Allen Fellowship in Cornell News**, December 2008. ([Link](#))

## **Invited Talks (Limited List)**

ICML 2016 Deep learning workshop, Southern California ML symposium ([Link](#)). Keynote at ICLR 2016. NIPS 2015 Workshop on Nonconvex Optimization. ([Link](#)). Strata+Hadoop ([Link 1](#)), ([Link 2](#)). Simons Workshops ([Link 1](#)), ([Link 2](#)). Fields Institute workshop ([Link](#)).

Tutorials at ICML 2016 ([Link](#)). Summer school on Econometrics 2016 ([Link](#)). MLSS 2014 ([Link](#)). AAAI 2014. ICML 2013.

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<http://newport.eecs.uci.edu/anandkumar/Resume/CV.pdf>