

# Sushant Sachdeva

Assistant Professor, University of Toronto

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## RESEARCH INTERESTS

### Algorithms, and its connections to learning, optimization, and statistics

My research is focused on the design of fast algorithms for problems ranging from theoretical computer science to machine learning and statistics. My work brings together tools from convex optimization, numerical linear algebra, and approximation theory.

## APPOINTMENTS

### University of Toronto

Toronto, ON, Canada

Assistant Professor, Department of Computer Science

Aug 2017 – Present

### Institute for Advanced Study

Princeton, NJ, USA

Visitor

Fall 2019

Special year on Optimization, Statistics, and Theoretical Machine Learning

### Google

Mountain View, CA, USA

Research Scientist

Aug 2016 – Aug 2017

### Yale University

New Haven, CT, USA

Postdoctoral Associate, Department of Computer Science

Jan 2014 – Jul 2016

Supervisor: Prof. Daniel Spielman

Lecturer, Department of Computer Science

Jan 2015 – May 2015

### UC Berkeley, Simons Institute for the Theory of Computing

Berkeley, CA, USA

Simons Research Fellow

Aug 2013 – Dec 2013

Program: Real Analysis in Computer Science

## EDUCATION

### Princeton University

Princeton, NJ, USA

Ph.D., Department of Computer Science

Sep 2008 – Sep 2013

Thesis: New Results in the Theory of Approximation — Fast Graph Algorithms and Inapproximability

Adviser: Prof. Sanjeev Arora

M.A., Department of Computer Science

Sep 2008 – Jun 2010

### Indian Institute of Technology Bombay

Mumbai, India

B.Tech., Department of Computer Science and Engineering

Jul 2004 – Aug 2008

Adviser: Sundar Vishwanathan

CPI: 9.97/10.00

## HONORS AND AWARDS

**NSERC Discovery Grant** 2018-2023 (CAD 172,500)

Connaught New Researcher Award 2018 (CAD 10,000)

**Google Faculty Research Award**, 2017 (USD 43,335)

**Simons-Berkeley Research Fellowship**, Fall 2013 (USD 26,466)

Postdoctoral Research Fellowship by Institute for Computational and Experimental Research in Mathematics (2013-2014, USD 50,000 – declined)

**President of India Gold Medal** for topping the class of 2008 (of 500+ students)

Jayanti Deshmukh Memorial Gold Medal for being the most outstanding B.Tech. student in the computer science class of 2008 (out of 35 students)

Honorable Mention at **ACM ICPC World Finals, Tokyo 2007** representing IIT Bombay

**1st all over India** in IIT Entrance Examination 2004 (among 170,000+ students)

**Bronze Medalist** at 36<sup>th</sup> International Chemistry Olympiad (ICHO) 2004, Kiel, Germany

Perfect SPI of 10.0 in 7 semesters out of 8 at IIT Bombay

AP grade for outstanding performance in ten courses at IIT Bombay

Aditya Birla Scholarship 2004–08, covering my undergraduate studies. It is awarded to only 10 engineering students each year.

Dhirubai Ambani Scholarship 2004–08 for being among the top 10 students of Maharashtra state in AISSCE 2004.

Kishore Vaigyanik Protsahan Yojana (KVPY) fellowship 2002–04. Awarded to around 50 students each year; aimed at promoting research careers in the sciences.

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| MONOGRAPHS   | <p><i>Faster Algorithms via Approximation Theory</i><br/>S. Sachdeva, N. K. Vishnoi<br/>In Foundations and Trends in Theoretical Computer Science 9.2 (FTTCS) 2014, pp. 125-210</p>   |
| REFEREED<br>JOURNAL<br>PUBLICATIONS                  | <p><i>The mixing time of the Dikin walk in a polytope – A simple proof</i><br/>S. Sachdeva, N. Vishnoi<br/>In Operations Research Letters, 44.5 (September 2016), pp. 630–634</p> <p><i>An Arithmetic Analogue of Fox’s Triangle Removal Argument</i><br/>P. Hatami, S. Sachdeva, M. Tulsiani<br/>In Online Journal of Analytic Combinatorics 11 (OJAC) 2016</p> <p><i>Provable ICA with Unknown Gaussian Noise, and Implications for Gaussian Mixtures and Autoencoders</i><br/>S. Arora, R. Ge, A. Moitra, S. Sachdeva<br/>In Algorithmica 72.1 (May 2015), pp. 215–236</p> <p><i>Inapproximability of Minimum Vertex Cover on <math>k</math>-Uniform <math>k</math>-Partite Hypergraphs</i><br/>V. Guruswami, S. Sachdeva, R. Saket<br/>In SIAM Journal on Discrete Mathematics 29.1 (SIDMA) 2015, pp. 36–58</p> <p><i>Greedy Geometric Algorithms for Collection of Balls, with Applications to Geometric Approximation and Molecular Coarse-Graining</i><br/>F. Cazals, T. Dreyfus, S. Sachdeva, N. Shah<br/>In Computer Graphics Forum 33–6, 2014</p> <p><i>On the Characterization and Selection of Diverse Conformational Ensembles with Applications to Flexible Docking</i><br/>S. Lorient, S. Sachdeva, K. Bastard, C. Prevost, F. Cazals<br/>In Computational Biology and Bioinformatics, IEEE/ACM Transactions on 8.2 (TCBB) 2011, pp. 487–498</p> |
| REFEREED<br>CONFERENCE /<br>WORKSHOP<br>PUBLICATIONS | <p><i>Faster <math>p</math>-norm minimizing flows, via smoothed <math>q</math>-norm problems</i><br/>D. Adil, S. Sachdeva<br/>To appear at 31<sup>th</sup> ACM-SIAM Symposium on Discrete Algorithms (SODA) 2020</p> <p><i>Fast, Provably convergent IRLS Algorithm for <math>p</math>-norm Linear Regression</i><br/>D. Adil, R. Peng, S. Sachdeva<br/>To appear at 33rd Conference on Neural Information Processing Systems (NeurIPS) 2019</p> <p><i>Which Algorithmic Choices Matter at Which Batch Sizes? Insights From a Noisy Quadratic Model</i><br/>G. Zhang, L. Li, Z. Nado, J. Martens, S. Sachdeva, G. Dahl, C. Shallue, R. Grosse<br/>To appear at 33rd Conference on Neural Information Processing Systems (NeurIPS) 2019</p> <p><i>Flows in Almost Linear Time via Adaptive Preconditioning</i><br/>R. Kyng, R. Peng, S. Sachdeva, D. Wang<br/>In 51<sup>st</sup> ACM Symposium on Theory of Computing (STOC) 2019</p>  |

*Improved Semi-Supervised Learning with Multiple Graphs*

K. Viswanathan\*, S. Sachdeva\*, A. Tomkins, S. Ravi (\*=equal contribution)

In 22nd International Conference on Artificial Intelligence and Statistics (AISTATS) 2019

*Iterative Refinement for  $\ell_p$ -norm Regression*

D. Adil, R. Kyng, R. Peng, S. Sachdeva

In 30<sup>th</sup> ACM-SIAM Symposium on Discrete Algorithms (SODA) 2019

*Short Cycles via Low-Diameter Decompositions*

Y. P. Liu, S. Sachdeva, Z. Yu

In 30<sup>th</sup> ACM-SIAM Symposium on Discrete Algorithms (SODA) 2019

*Graph Sparsification, Spectral Sketches, and Faster Resistance Computation, via Short Cycle Decompositions*

T. Chu, Y. Gao, R. Peng, S. Sachdeva, S. Sawlani, J. Wang

To appear at 59<sup>th</sup> IEEE Symposium on Foundations of Computer Science (FOCS) 2018

Invited to SIAM Journal on Computing **Special Issue**

Invited to **Highlights of Algorithms 2019**

*Convergence Results for Neural Networks via Electrodynamics*

R. Panigrahy, A. Rahimi, S. Sachdeva, Q. Zhang

In 9<sup>th</sup> Innovations in Theoretical Computer Science (ITCS) 2018

*Near-optimal approximation algorithm for simultaneous Max-Cut*

A. Bhangale, S. Khot, S. Kopparty, S. Sachdeva, D. Thiruvengatachari

In 29<sup>th</sup> ACM-SIAM Symposium on Discrete Algorithms (SODA) 2018

*Sampling Random Spanning Trees Faster than Matrix Multiplication*

D. Durfee, R. Kyng, J. Peebles, A. B. Rao, S. Sachdeva

In 49<sup>th</sup> ACM Symposium on Theory of Computing (STOC) 2017

*A framework for analyzing resparsification algorithms*

R. Kyng, J. Pachocki, R. Peng, S. Sachdeva

In 28<sup>th</sup> ACM-SIAM Symposium on Discrete Algorithms (SODA) 2017

*Approximate Gaussian Elimination for Laplacians: Fast, Sparse, and Simple*

R. Kyng, S. Sachdeva

In 57<sup>th</sup> IEEE Symposium on Foundations of Computer Science (FOCS) 2016

Invited to **Highlights of Algorithms 2017**

*Sparsified Cholesky and Multigrid Solvers for Connection Laplacians*

R. Kyng, Y. T. Lee, R. Peng, S. Sachdeva, and D. A. Spielman

In 48<sup>th</sup> ACM Symposium on Theory of Computing (STOC) 2016

*Fast, Provable Algorithms for Isotonic Regression in all  $\ell_p$ -norms*

R. Kyng, A. B. Rao, S. Sachdeva

In 29<sup>th</sup> Advances in Neural Information Processing Systems (NIPS) 2015

*Algorithms for Lipschitz Learning on Graphs*

R. Kyng, A. B. Rao, S. Sachdeva, D. A. Spielman

In 28<sup>th</sup> Conference on Learning Theory (COLT) 2015

*Simultaneous Approximation of Constraint Satisfaction Problems*

A. Bhangale, S. Kopparty, S. Sachdeva

In 42<sup>nd</sup> International Colloquium on Automata, Languages, and Programming (ICALP) 2015

*Optimal Inapproximability for Scheduling Problems via Structural Hardness for Hypergraph Vertex Cover*

S. Sachdeva, R. Saket

In 28<sup>th</sup> IEEE Conference on Computational Complexity (CCC) 2013

*Approximating the Exponential, the Lanczos Method and an  $\tilde{O}(m)$ -Time Spectral Algorithm for Balanced Separator*

L. Orecchia, S. Sachdeva, N. K. Vishnoi

In 44<sup>th</sup> ACM Symposium on Theory of Computing (STOC) 2012

*Provable ICA with Unknown Gaussian Noise, and Implications for Gaussian Mixtures and Autoencoders*

S. Arora, R. Ge, A. Moitra, S. Sachdeva

In 26<sup>th</sup> Advances in Neural Information Processing Systems (NIPS) 2012

Invited to **Algorithmica Special Issue for Machine Learning**

*Finding Overlapping Communities in Social Networks: Towards a Rigorous Approach*

S. Arora, R. Ge, S. Sachdeva, G. Schoenebeck

In 13<sup>th</sup> ACM Conference on Electronic Commerce (EC) 2012

*Testing Permanent Oracles — Revisited*

S. Arora, A. Bhattacharyya, R. Manokaran, S. Sachdeva

In 16<sup>th</sup> International Workshop on Randomization and Computation (RANDOM) 2012

*Nearly Optimal NP-Hardness of Vertex Cover on  $k$ -Uniform  $k$ -Partite Hypergraphs*

S. Sachdeva, R. Saket

In 14<sup>th</sup> International Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX) 2011

#### THESES

*New Results in the Theory of Approximation: Fast Graph Algorithms and Inapproximability*

Ph.D. Thesis, Princeton University, 2013. Advised by Sanjeev Arora

*On the Hardness of Approximating Vertex Cover*

B.Tech. Thesis, IIT Bombay, 2008. Advised by Sundar Vishwanathan

#### SELECT

*Cuts in Cartesian Products of Graphs*

#### MANUSCRIPTS

S. Sachdeva, M. Tulsiani

#### SUPERVISION

*Graduate students:*

Deeksha Adil (M.Sc. student, UToronto, 2017-2019, Ph.D. student, 2019–)

*Undergraduate students:*

Zejun Yu (UToronto, Summer 2018)

*Mentees:*

Yang P. Liu (Summer 2018). Graduate student, Stanford.

Joshua Wang (Summer 2017). Research Scientist, Google.

Qiuqi (Richard) Zhang (Fall 2016). Software Engineer, Google.

Xiao Shi (Fall 2015). Software Engineer, Facebook.

#### TALKS

*Faster  $p$ -norm minimizing flows, via smoothed  $q$ -norm problems*

Symposium on Discrete Algorithms (SODA), Salt Lake City, Jan 2020

*Fast IRLS Algorithms for  $p$ -norm regression*

Institute for Advanced Study, Princeton, Nov 2019

Theory Seminar, Yale University, Nov 2019

*Graph Sparsifiers via Short-Cycle Decompositions*

Institute for Advanced Study, Princeton, Dec 2019

Highlights of Algorithms, Copenhagen, Jun 2019

*Improved  $\ell_p$ -norm Optimization via Iterative Refinement*

Seminar, Indian Institute of Technology, Mumbai, Sep 2019

Seminar, Indian Institute of Technology, Delhi, Sep 2019

Theory Seminar, Northwestern, Evanston, Feb 2019

Theory Seminar, UChicago / TTIC, Chicago, Feb 2019

STOCA Workshop, Google Mountain View, Feb 2019

*Approximate Gaussian Elimination and Applications*

Laplacian 2.0 Workshop, FOCS 2018, Paris, Oct 2018

*Fast Approximate Gaussian Elimination for Laplacians*

High Performance Graph Algorithms, Dagstuhl Seminar, Germany, Jun 2018

Canada Applied and Industrial Mathematics Society (CAIMS), Toronto, Jun 2018

Department Seminar, University of Waterloo, Nov 2017

Highlights of Algorithms, Berlin, Jun 2017

Simons Collaboration on Algorithms & Geometry, New York, Mar 2017

TOCA-SV, Stanford, Nov 2016

TCS Plus Seminar, Sep 2016

Theory of Computation Seminar, Harvard University, Sep 2016

Theory Lunch, Boston University, Sep 2016

*Fast Algorithms for Optimization and Learning on Graphs*

Google, New York, May 2016

Computer Science Colloquium, Purdue University, Apr 2016

Department of Computer Science Lecture, University of Toronto, Canada, Mar 2016

Computer Science Seminar, University of Colorado Boulder, Mar 2016

*Regression on Graphs – Lipschitz and Isotonic*

Simons Seminar, University of Texas Austin, May 2016

University of Chicago, Scientific and statistical computing seminar, Nov 2015

*Lipschitz Learning on Graphs*

Theory seminar, CS Department, Carnegie Mellon University, Nov 2016

IIT Bombay, CS department seminar, Jul 2015

EPFL (École Polytechnique Fédérale de Lausanne) INF department seminar, Jul 2015

Conference on Learning Theory (COLT), Paris, Jul 2015

UC San Diego, CS department theory seminar, May 2015

Yale University, Statistics department seminar, Apr 2015

*Triangle Removal in Groups*

Simons Institute, UC Berkeley, Real analysis seminar, Nov 2013

Institute for Advanced Study (IAS) Computer science/discrete mathematics seminar, Apr 2013

*Generalizations of KKL Theorem and Friedgut’s Junta Theorem*

Simons Institute, UC Berkeley, Real analysis workshop, Aug 2013

*Hardness for Scheduling Problems*

Conference on Computational Complexity (CCC), Palo Alto, Jun 2013

*Near-linear Time Algorithms for Balanced Separator*

Rutgers University, DIMACS/CS theoretical computer science seminar, Mar 2013

University of Washington, ETP theory connections, Aug 2012

Symposium on Theory of Computing (STOC), New York, May 2012

Institute for Advanced Study (IAS) Computer science/discrete mathematics seminar, Apr 2012

*Testing Permanent Oracles*

International Workshop on Randomization and Computation (RANDOM), Boston, Aug 2012

PROFESSIONAL  
SERVICE

*Editor:*

Siam Journal on Computing (SICOMP) STOC 2019 special issue

*Program Committee:*

Symposium on Theory of Computing (STOC) 2019, Phoenix, AZ, USA

*Organizer:*

Workshop ‘Laplacians 2.0’, FOCS 2018, Paris, France

*Reviewer:* COLT 2019, ICML 2019, ICALP 2019, STOC 2019, SODA 2019, FOCS 2018, NIPS 2018, SICOMP, STOC 2018, ICLR 2018, ICALP 2018, SODA 2018, ICML 2018, FOCS 2017, WADS 2017, SPAA 2017, APPROX 2017, NIPS 2017, STOC 2017, SODA 2017, FOCS 2016, NIPS 2016, STOC 2016, SODA 2016, STOC 2015, SODA 2015, SIDMA, QIC, Random 2014,

FOCS 2014, STOC 2014, FSTTCS 2013, SODA 2014, Approx 2013, TOC, Algorithmica, ITCS 2013, SODA 2013, ICALP 2012, LATIN 2012, SODA 2012, FSTTCS 2011

TEACHING EXPERIENCE	<b>Assistant Professor, University of Toronto</b>	
	<i>Instructor for CSC 263H5 : Data Structures and Analysis</i>	Winter 2018
	Teaching evaluation score : 4.4/5.0	
	<i>Instructor for CSC 2421H : Fast Algorithms via Continuous Methods</i>	Fall 2017
	Teaching evaluation score : 4.5/5.0	
	<b>Lecturer, Yale University</b>	
	<i>Lecturer for CPSC 665 : An Algorithmist's toolkit</i>	Spring 2015
	Designed and taught a full course on advanced algorithms (2 lectures a week)	
	<b>55% of students rated the course excellent (highest rating)</b>	
	<b>Teaching Assistant, Princeton University</b>	
PROFESSIONAL EXPERIENCE	<i>Assistant in Instruction for COS 433: Cryptography</i>	Spring 2010
	<i>Assistant in Instruction for COS 340: Reasoning About Computation</i>	Fall 2009
	<b>Toyota Technological Institute</b>	
	Chicago, IL	
	Research Intern, Summer 2012	
	Supervisor: Yury Makarychev	
	Lower bounds for Vertex Sparsifiers.	
	<b>Microsoft Research India</b>	
	Bangalore, India	
	Research Intern, Summer 2011	
	Supervisor: Nisheeth K. Vishnoi	
	Fast algorithms for Balanced Separator.	
	<b>INRIA</b>	
	Sophia-Antipolis, France	
	Research Intern, Summer 2007	
	Supervisor: Frederic Cazals (Research Director, Geometrica group).	
	Selecting a representative set of protein conformers.	
	<b>ETH</b>	
	Zurich, Switzerland	
	Research Intern, Summer 2006	
REFERENCES	Supervisor: Riko Jacob (Algorithms, Data Structures, and Applications group).	
	Cache efficiency of shortest path algorithms with preprocessing.	
	Prof. Daniel Spielman ( <a href="mailto:spielman@cs.yale.edu">spielman@cs.yale.edu</a> )	
	Henry Ford II Professor of Computer Science, Mathematics, and Applied Mathematics	
	Yale University	
	Prof. Sanjeev Arora ( <a href="mailto:arora@cs.princeton.edu">arora@cs.princeton.edu</a> )	
	Charles C. Fitzmorris Professor of Computer Science	
	Princeton University	
	(Please contact admin. assistant Mitra Kelly at <a href="mailto:mkelly@cs.princeton.edu">mkelly@cs.princeton.edu</a> )	
	Prof. Nisheeth K. Vishnoi ( <a href="mailto:nisheeth.vishnoi@epfl.ch">nisheeth.vishnoi@epfl.ch</a> )	
	Associate Professor of Computer Science	
	EPFL (École Polytechnique Fédérale de Lausanne)	
	Prof. Jonathan Kelner ( <a href="mailto:kelner@mit.edu">kelner@mit.edu</a> )	
	Mark Hyman, Jr. Career Development Associate Professor of Applied Mathematics	
	MIT (Massachusetts Institute of Technology)	