Sushant Sachdeva

Assistant Professor, University of Toronto

https://www.cs.toronto.edu/~sachdeva/

sachdeva@cs.toronto.edu

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

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^{th} International Chemistry Olympiad (IChO) 2004, Kiel, Germany

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.

Monographs

Faster Algorithms via Approximation Theory
S. Sachdeva, N. K. Vishnoi
In Foundations and Trends in Theoretical Computer Science 9.2 (FTTCS) 2014, pp. 125-210

Refereed Journal Publications

Graph Sparsification, Spectral Sketches, and Faster Resistance Computation via Short Cycle Decompositions
T. Chu, Y. Gao, R. Peng, S. Sachdeva, S. Sawlani, J. Wang
SIAM Journal on Computing, FOCS 2018 Special Issue (2020), pp. 85–157

The mixing time of the Dikin walk in a polytope – A simple proof
S. Sachdeva, N. Vishnoi
In Operations Research Letters, 44.5 (September 2016), pp. 630–634

An Arithmetic Analogue of Fox's Triangle Removal Argument
P. Hatami, S. Sachdeva, M. Tulsiani
In Online Journal of Analytic Combinatorics 11 (OJAC) 2016

Provable ICA with Unknown Gaussian Noise, and Implications for Gaussian Mixtures and Autoencoders
S. Arora, R. Ge, A. Moitra, S. Sachdeva
In Algorithmica 72.1 (May 2015), pp. 215–236

Inapproximability of Minimum Vertex Cover on k-Uniform k-Partite Hypergraphs
V. Guruswami, S. Sachdeva, R. Saket
In SIAM Journal on Discrete Mathematics 29.1 (SIDMA) 2015, pp. 36–58

Greedy Geometric Algorithms for Collection of Balls, with Applications to Geometric Approximation and Molecular Coarse-Graining
F. Cazals, T. Dreyfus, S. Sachdeva, N. Shah
In Computer Graphics Forum 33–6, 2014

On the Characterization and Selection of Diverse Conformational Ensembles with Applications to Flexible Docking
S. Loriot, S. Sachdeva, K. Bastard, C. Prevost, F. Cazals
In Computational Biology and Bioinformatics, IEEE/ACM Transactions on 8.2 (TCBB) 2011, pp. 487–498

Refereed Conference / Workshop Publications

Almost-linear-time Weighted ℓ_p-norm Solvers in Slightly Dense Graphs via Sparsification.
D. Adil, B. Bullins, R, Kyng, S. Sachdeva
In 48$^{\text{nd}}$ International Colloquium on Automata, Languages, and Programming (ICALP) 2021

Regularized linear autoencoders recover the principal components, eventually
X. Bao, J. Lucas, S. Sachdeva, R. Grosse
In 33rd Conference on Neural Information Processing Systems (NeurIPS) 2020

Faster Graph Embeddings via Coarsening
M. Fahrbach, G. Goranci, S. Sachdeva, R. Peng, C. Wang
In 37th International Conference on Machine Learning (ICML) 2020

Faster p-norm minimizing flows, via smoothed q-norm problems
D. Adil, S. Sachdeva
In 31$^{\text{th}}$ ACM-SIAM Symposium on Discrete Algorithms (SODA) 2020

Fast, Provably convergent IRLS Algorithm for p-norm Linear Regression
D. Adil, R. Peng, S. Sachdeva
In 33rd Conference on Neural Information Processing Systems (NeurIPS) 2019

Which Algorithmic Choices Matter at Which Batch Sizes? Insights From a Noisy Quadratic Model
G. Zhang, L. Li, Z. Nado, J. Martens, S. Sachdeva, G. Dahl, C. Shallue, R. Grosse
In 33rd Conference on Neural Information Processing Systems (NeurIPS) 2019

Flows in Almost Linear Time via Adaptive Preconditioning
R. Kyng, R. Peng, S. Sachdeva, D. Wang
In 51$^{\text{st}}$ ACM Symposium on Theory of Computing (STOC) 2019

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 ℓ_p-norm Regression
D. Adil, R. Kyng, R. Peng, S. Sachdeva
In 30$^{\text{th}}$ ACM-SIAM Symposium on Discrete Algorithms (SODA) 2019

Short Cycles via Low-Diameter Decompositions
Y. P. Liu, S. Sachdeva, Z. Yu
In 30$^{\text{th}}$ 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
In 59$^{\text{th}}$ 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$^{\text{th}}$ Innovations in Theoretical Computer Science (ITCS) 2018

Near-optimal approximation algorithm for simultaneous Max-Cut
A. Bhangale, S. Khot, S. Kopparty, S. Sachdeva, D. Thiruvenkatachari
In 29$^{\text{th}}$ 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$^{\text{th}}$ ACM Symposium on Theory of Computing (STOC) 2017

A framework for analyzing resparsification algorithms
R.Kyng, J. Pachocki, R. Peng, S. Sachdeva
In 28$^{\text{th}}$ ACM-SIAM Symposium on Discrete Algorithms (SODA) 2017

Approximate Gaussian Elimination for Laplacians: Fast, Sparse, and Simple
R. Kyng, S. Sachdeva
In 57$^{\text{th}}$ 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$^{\text{th}}$ ACM Symposium on Theory of Computing (STOC) 2016

Fast, Provable Algorithms for Isotonic Regression in all ℓ_p-norms
R. Kyng, A. B. Rao, S. Sachdeva
In 29$^{\text{th}}$ 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 28th Conference on Learning Theory (COLT) 2015

Simultaneous Approximation of Constraint Satisfaction Problems
A. Bhangale, S. Kopparty, S. Sachdeva
In 42nd 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 28th IEEE Conference on Computational Complexity (CCC) 2013

Approximating the Exponential, the Lanczos Method and an $\widetilde{O}(m)$-Time Spectral Algorithm for Balanced Separator
L. Orecchia, S. Sachdeva, N. K. Vishnoi
In 44th 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 26th 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 13th ACM Conference on Electronic Commerce (EC) 2012

Testing Permanent Oracles — Revisited
S. Arora, A. Bhattacharyya, R. Manokaran, S. Sachdeva
In 16th 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 14th 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 Manuscripts

Cuts in Cartesian Products of Graphs
S. Sachdeva, M. Tulsiani

Supervision

Graduate students:
Yibin Zhao (Ph.D. student, UToronto, 2020–)
Lawrence Li (Ph.D. student, UToronto, 2020–)
Deeksha Adil (M.Sc. student, UToronto, 2017–2019, Ph.D. student, 2019–)

Postdocs:
Gramoz Goranci (2020–)

Undergraduate students:
Devansh Ranade (UToronto, 2020–)
Jack McKinney (UToronto, Summer 2020)
Zejun Yu (UToronto, Summer 2018)

Mentees:
Yang P. Liu (Summer 2018). Graduate student, Stanford.
Joshua Wang (Summer 2017). Research Scientist, Google.
Qiuyi (Richard) Zhang (Fall 2016). Software Engineer, Google.
Xiao Shi (Fall 2015). Software Engineer, Facebook.

Talks

Improved ℓ_p-norm Optimization via Iterative Refinement
Theory Seminar, University of Washington, Seattle, Apr 2021
Theory Seminar, Carnegie Mellon University, Pittsburgh, Feb 2021
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

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
Fuji Co-creation Lab, University of Toronto, May 2020
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

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:
ACM Transactions of Algorithms (TALG) SODA 2021 special issue
SIAM Journal on Computing (SICOMP) STOC 2019 special issue

Program Committee:
ACM-SIAM Symposium on Discrete Algorithms (SODA) 2021
Symposium on Theory of Computing (STOC) 2019

Organizer:
Workshop 'Laplacians 2.0', FOCS 2018, Paris, France

Conference Reviewing: STOC (2014–2020), FOCS (2014–2020), SODA (2012–2020), CCC 2020, COLT 2018–2019, ESA 2019, NeurIPS / NIPS (2016–2019), ICML (2018–2020), ITCS (2013, 2020), ICLR 2018, ICALP (2012, 2018–2019), APPROX (2013, 2017), RANDOM (2019, 2014), WADS 2017, SPAA 2017, FSTTCS (2011, 2013), LATIN 2012, QIC 2015

Journal Reviewing: Siam Journal on Discrete Mathematics (SIDMA), Algorithmica, Theory of Computing, Siam Journal on Computing (SICOMP)

Teaching Experience

Assistant Professor, University of Toronto

Instructor for CSC 263H5 : Data Structures and Analysis — Winter 2018–2021

Instructor for CSC 2421H : Graphs, Matrices, and Optimization — Fall 2018, Winter 2021

Instructor for CSC 2421H : Fast Algorithms via Continuous Methods — Fall 2017

Lecturer, Yale University

Lecturer for CPSC 665 : An Algorithmist's toolkit — Spring 2015
Designed and taught a full course on advanced algorithms (2 lectures a week)
55% of students rated the course excellent (highest rating)

Teaching Assistant, Princeton University

Assistant in Instruction for COS 433: Cryptography — Spring 2010
Assistant in Instruction for COS 340: Reasoning About Computation — Fall 2009

Professional Experience

Toyota Technological Institute — Chicago, IL
Research Intern. Supervisor: Yury Makarychev — Summer 2012

Microsoft Research India — Bangalore, India
Research Intern. Supervisor: Nisheeth K. Vishnoi — Summer 2011

INRIA — Sophia-Antipolis, France
Research Intern. Supervisor: Frederic Cazals — Summer 2007

ETH — Zurich, Switzerland
Research Intern. Supervisor: Riko Jacob — Summer 2006

References

Prof. Daniel Spielman (spielman@cs.yale.edu)
Henry Ford II Professor of Computer Science, Mathematics, and Applied Mathematics
Yale University

Prof. Sanjeev Arora (arora@cs.princeton.edu)
Charles C. Fitzmorris Professor of Computer Science
Princeton University
(Please contact admin. assistant Mitra Kelly at mkelly@cs.princeton.edu)

Prof. Nisheeth K. Vishnoi (nisheeth.vishnoi@epfl.ch)
Associate Professor of Computer Science
EPFL (École Polytechnique Fédérale de Lausanne)

Prof. Jonathan Kelner (kelner@mit.edu)
Mark Hyman, Jr. Career Development Associate Professor of Applied Mathematics
MIT (Massachusetts Institute of Technology)