Sushant Sachdeva

Associate Professor, University of Toronto

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

sachdeva@cs.toronto.edu

Research Interests

Algorithms, and its connections to optimization and statistics

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

Appointments

2017 – Present **University of Toronto**

2023 – Present Associate Professor (with tenure), Mathematical and Computational Sciences
Associate Professor (with tenure), Department of Computer Science

2017 – 2023 Assistant Professor, Mathematical and Computational Sciences
Assistant Professor, Department of Computer Science

2019 – Present **Vector Institute**, Faculty Affiliate

Fall 2019 **Institute for Advanced Study**, Visitor

2016 – 2017 **Google**, Research Scientist

2014 – 2016 **Yale University**, Postdoctoral Associate

Supervisor: Prof. Daniel Spielman

Fall 2013 **UC Berkeley**, Simons Research Fellow

Education

2008 – 2013 **Princeton University**

Ph.D., M.A., Department of Computer Science
Advisor: Prof. Sanjeev Arora

2004 – 2008 **Indian Institute of Technology Bombay**

B.Tech., Department of Computer Science and Engineering

Honors and Awards

2023 **Sloan Research Fellowship** (USD 75,000)

2023 **Frontiers of Science Award** at the International Congress on Basic Sciences, Beijing, 2023.

2023 Invited long-term Participant for Fall 2023, Simons Institute UC Berkeley

2023 **Young Alumni Achiever Award**, Indian Institute of Technology Bombay (IITB)

2023 **Invited Plenary Speaker** at SODA 2023

2022 **Best Paper Award** at FOCS 2022

2022 **Ontario Early Researcher Award** 2022-27 (CAD 150,000)

2021 **MITACS Accelerate Grant** 2021 (CAD 65,000)

2018 **NSERC Discovery Grant** 2018-2024 (CAD 210,500)

2018 Connaught New Researcher Award 2018 (CAD 10,000)

2018 **Google Faculty Research Award**, 2017 (USD 43,335)

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

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

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

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

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

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

2004 **Bronze Medalist** at 36^{th} International Chemistry Olympiad (IChO) 2004, Kiel, Germany

2004 Aditya Birla Scholarship 2004–08, awarded to only 10 engineering students each year.

2004 Dhirubai Ambani Scholarship 2004–08, awarded to top 10 students in Maharashtra state

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

Monographs

2014 *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

SICOMP 2020 *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

ORLetters 2016 *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

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

Algorithmica 2015 *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

SIDMA 2015 *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

CGF 2014 *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

TCBB 2011 *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

FOCS 2023 *A Deterministic Almost-Linear Time Algorithm for Minimum-Cost Flow*
Jvd. Brand, L. Chen, R. Kyng. Y. P. Liu, R. Peng, M. P. Gutenberg, S. Sachdeva, A. Sidford

SPAA 2023 *A Simple and Efficient Parallel Laplacian Solver*
S. Sachdeva, Y. Zhao

SOSA 2023 *A Simple Framework for Finding Balanced Sparse Cuts via APSP*
L. Chen, R. Kyng, M. Probst Gutenberg, S. Sachdeva

SODA 2023 *A New Approach to Estimating Effective Resistances & Counting Spanning Trees in Expanders*
L. Li, S. Sachdeva

FOCS 2022 *Maximum Flow and Minimum-Cost Flow in Almost-Linear Time*
L. Chen, R. Kyng. Y. P. Liu, R. Peng, M. P. Gutenberg, S. Sachdeva
Best Paper Award at FOCS 2022
Frontiers of Science Award 2023
Invited to **J.ACM**
Invited to **Highlight of Algorithms 2023**

ICML 2022 *A Convergent and Dimension-Independent Min-Max Optimization Algorithm*
V. Keswani, O. Mangoubi, S. Sachdeva, N. K. Vishnoi

SODA 2022 *Nested Dissection Meets IPMs: Planar Min-Cost Flow in Nearly Linear Time*
S. Dong, Y. Gao, G. Goranci, Y.T. Lee, R. Peng, S. Sachdeva, G. Ye

NeurIPS 2021 *Unifying Width-Reduced Methods for Quasi-Self-Concordant Optimization*
D. Adil, B. Bullins, S. Sachdeva

ICALP 2021 *Almost-linear-time Weighted ℓ_p-norm Solvers in Slightly Dense Graphs via Sparsification.*
D. Adil, B. Bullins, R, Kyng, S. Sachdeva

NeurIPS 2020 *Regularized linear autoencoders recover the principal components, eventually*
X. Bao, J. Lucas, S. Sachdeva, R. Grosse

ICML 2020 *Faster Graph Embeddings via Coarsening*
M. Fahrbach, G. Goranci, S. Sachdeva, R. Peng, C. Wang

SODA 2020 *Faster p-norm minimizing flows, via smoothed q-norm problems*
D. Adil, S. Sachdeva

NeurIPS 2019 *Fast, Provably convergent IRLS Algorithm for p-norm Linear Regression*
D. Adil, R. Peng, S. Sachdeva

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

STOC 2019 *Flows in Almost Linear Time via Adaptive Preconditioning*
R. Kyng, R. Peng, S. Sachdeva, D. Wang

AISTATS 2019 *Improved Semi-Supervised Learning with Multiple Graphs*
K. Viswanathan*, S. Sachdeva*, A. Tomkins, S. Ravi (*=equal contribution)

SODA 2019 *Iterative Refinement for ℓ_p-norm Regression*
D. Adil, R. Kyng, R. Peng, S. Sachdeva

SODA 2019 *Short Cycles via Low-Diameter Decompositions*
Y. P. Liu, S. Sachdeva, Z. Yu

FOCS 2018 *Graph Sparsification, Spectral Sketches, and Faster Resistance Computation, via Short Cycle Decompositions*
T. Chu, Y. Gao, R. Peng, S. Sachdeva, S. Sawlani, J. Wang
Invited to SIAM Journal on Computing **Special Issue**
Invited to **Highlights of Algorithms 2019**

ITCS 2018 *Convergence Results for Neural Networks via Electrodynamics*
R. Panigrahy, A. Rahimi, S. Sachdeva, Q. Zhang

SODA 2018 *Near-optimal approximation algorithm for simultaneous Max-Cut*
A. Bhangale, S. Khot, S. Kopparty, S. Sachdeva, D. Thiruvenkatachari

STOC 2017 *Sampling Random Spanning Trees Faster than Matrix Multiplication*
D. Durfee, R. Kyng, J. Peebles, A. B. Rao, S. Sachdeva

SODA 2017 *A framework for analyzing resparsification algorithms*
R.Kyng, J. Pachocki, R. Peng, S. Sachdeva

FOCS 2016 *Approximate Gaussian Elimination for Laplacians: Fast, Sparse, and Simple*
R. Kyng, S. Sachdeva
Invited to **Highlights of Algorithms 2017**

STOC 2016 *Sparsified Cholesky and Multigrid Solvers for Connection Laplacians*
R. Kyng, Y. T. Lee, R. Peng, S. Sachdeva, and D. A. Spielman

NIPS 2015 *Fast, Provable Algorithms for Isotonic Regression in all ℓ_p-norms*
R. Kyng, A. B. Rao, S. Sachdeva

COLT 2015 *Algorithms for Lipschitz Learning on Graphs*
R. Kyng, A. B. Rao, S. Sachdeva, D. A. Spielman

ICALP 2015 *Simultaneous Approximation of Constraint Satisfaction Problems*
A. Bhangale, S. Kopparty, S. Sachdeva

CCC 2013 *Optimal Inapproximability for Scheduling Problems via Structural Hardness for Hypergraph Vertex Cover*
S. Sachdeva, R. Saket

STOC 2012 *Approximating the Exponential, the Lanczos Method and an $\widetilde{O}(m)$-Time Spectral Algorithm for Balanced Separator*
L. Orecchia, S. Sachdeva, N. K. Vishnoi

NIPS 2012 *Provable ICA with Unknown Gaussian Noise, and Implications for Gaussian Mixtures and Autoencoders*
S. Arora, R. Ge, A. Moitra, S. Sachdeva
Invited to **Algorithmica Special Issue for Machine Learning**

EC 2012 *Finding Overlapping Communities in Social Networks: Towards a Rigorous Approach*
S. Arora, R. Ge, S. Sachdeva, G. Schoenebeck

RANDOM 2012 *Testing Permanent Oracles — Revisited*
S. Arora, A. Bhattacharyya, R. Manokaran, S. Sachdeva

APPROX 2011 *Nearly Optimal NP-Hardness of Vertex Cover on k-Uniform k-Partite Hypergraphs*
S. Sachdeva, R. Saket

Theses

2013 *New Results in the Theory of Approximation: Fast Graph Algorithms and Inapproximability*
Ph.D. Thesis, Princeton University. Advised by Sanjeev Arora

2008 *On the Hardness of Approximating Vertex Cover*
B.Tech. Thesis, IIT Bombay. Advised by Sundar Vishwanathan

Supervision

Graduate students:
Lawrence Li (Ph.D. student, UToronto, 2020–)
Yibin Zhao (Ph.D. student, UToronto, 2020–)
Hantang Li (MScAC student, UToronto, 2023–)
Anthony Rinaldi (MScAC student, UToronto, 2023–)
Deepkamal Kaur Gill (MScAC student, UToronto, 2022–2023)
Hao Zhang (MScAC student, UToronto, 2021–22)
Deeksha Adil (M.Sc. student, UToronto, 2017–2019, Ph.D. student, 2019–2022)

Postdocs:
Gramoz Goranci (2020–2021). Assistant Professor at U. Vienna.

Undergraduate students:
Sasha Voitovych (UToronto, Winter 2023)
Anvith Thudi (UToronto, 2022–)
Devansh Ranade (UToronto, 2020–2021)
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.

Media Coverage

2022 Quanta Magazine, Researchers Achieve 'Absurdly Fast' Algorithm for Network Flow
Quanta Science Podcast, — : Apple, Google, Spotify

Talks

Linear Algebraic Perspective on Graphs
Aug 2023 Data Structures and Optimization for Fast Algorithms Bootcamp, Simons Institute, Berkeley

Almost-linear time Algorithms for Max-Flow and More
Feb 2023 Princeton University, Theory Lunch
Jan 2023 Symposium on Discrete Algorithms (SODA), Invited Plenary talk
Dec 2022 Tata Institute of Fundamental Research, STCS Seminar
Oct 2022 Institute for Advanced Study, Princeton
May 2022 Simons Institute for Theory of Computing, 10th Anniversary Symposium
May 2022 University of Toronto, Theory Seminar
Apr 2022 University of Texas Austin, Theory Seminar
Mar 2022 University of Waterloo, Theory Seminar
Mar 2022 IRIF Paris, Algorithms and Complexity Seminar

Improved ℓ_p-norm Optimization via Iterative Refinement
Apr 2021 University of Washington. Theory seminar
Feb 2021 Carnegie Mellon University, Theory seminar
Sep 2019 Indian Institute of Technology Bombay, Seminar
Sep 2019 Indian Institute of Technology Delhi, Seminar
Feb 2019 Northwestern University, Theory seminar
Feb 2019 University of Chicago / Toyota Technological Institute, Theory Seminar
Feb 2019 Google Mountain View, STOCA Workshop

Faster p-norm minimizing flows, via smoothed q-norm problems
Jan 2020 Symposium on Discrete Algorithms (SODA)

Fast IRLS Algorithms for p-norm regression

May 2020 University of Toronto, Fuji Co-creation Lab seminar
Nov 2019 Institute for Advanced Study, Princeton
Nov 2019 Yale University, Theory Seminar

Graph Sparsifiers via Short-Cycle Decompositions

Dec 2019 Institute for Advanced Study, Princeton
Jun 2019 Highlights of Algorithms, Copenhagen

Approximate Gaussian Elimination and Applications

Oct 2018 Laplacian 2.0 Workshop, FOCS 2018

Fast Approximate Gaussian Elimination for Laplacians

Jun 2018 Dagstuhl Seminar, Germany, High Performance Graph Algorithms
Jun 2018 Canada Applied and Industrial Mathematics Society (CAIMS), Toronto
Nov 2017 University of Waterloo, Department Seminar
Jun 2017 Highlights of Algorithms, Berlin
Mar 2017 Simons Collaboration on Algorithms & Geometry, New York
Nov 2016 TOCA-SV, Stanford University
Sep 2016 TCS Plus Seminar
Sep 2016 Harvard University, Theory of Computation Seminar
Sep 2016 Boston University, Theory Lunch

Fast Algorithms for Optimization and Learning on Graphs

May 2016 Google, New York
Apr 2016 Computer Science Colloquium, Purdue University
Mar 2016 Department of Computer Science Lecture, University of Toronto, Canada
Mar 2016 Computer Science Seminar, University of Colorado Boulder

Regression on Graphs – Lipschitz and Isotonic

May 2016 University of Texas Austin, Simons Seminar
Nov 2015 University of Chicago, Scientific and statistical computing seminar

Lipschitz Learning on Graphs

Nov 2016 Carnegie Mellon University, Theory seminar
Jul 2015 Indian Institute of Technology Bombay, CS department Seminar
Jul 2015 EPFL (École Polytechnique Fédérale de Lausanne) INF department seminar
Jul 2015 Conference on Learning Theory (COLT)
May 2015 University of California San Diego, CS department theory seminar
Apr 2015 Yale University, Statistics department seminar

Triangle Removal in Groups

Nov 2013 Simons Institute for Theory of Computing, Real analysis seminar
Apr 2013 Institute for Advanced Study (IAS) Computer science/discrete mathematics seminar

Generalizations of KKL Theorem and Friedgut's Junta Theorem

Aug 2013 Simons Institute for Theory of Computing, UC Berkeley, Real analysis workshop

Hardness for Scheduling Problems

Jun 2013 Conference on Computational Complexity (CCC)

Near-linear Time Algorithms for Balanced Separator

Mar 2013 Rutgers University, DIMACS/CS theoretical computer science seminar
Aug 2012 University of Washington, ETP theory connections
May 2012 Symposium on Theory of Computing (STOC)
Apr 2012 Institute for Advanced Study (IAS) Computer science/discrete mathematics seminar

Testing Permanent Oracles

Aug 2012 International Workshop on Randomization and Computation (RANDOM)

Professional Service

Editor:

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

Program Committee:

2023 Innovations in Theoretical Computer Science (ITCS) 2024
2023 IEEE Foundations of Computer Science (FOCS) 2023
2022 European Symposium on Algorithms (ESA) 2022
2022 ACM Symposium on Theory of Computing (STOC) 2022
2021 ACM-SIAM Symposium on Discrete Algorithms (SODA) 2021
2019 ACM Symposium on Theory of Computing (STOC) 2019

Organizer:

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

Conference Reviewing: STOC (2014–2020), FOCS (2014–2021), SODA (2012–2020), CCC 2020, COLT 2018–2019, ESA 2019, NeurIPS / NIPS (2016–2021), 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

Fall 2022 *Instructor for CSC 2240H : Graphs, Matrices, and Optimization*
Fall 2022 *Instructor for CSC 373H5 : Algorithm Design and Analysis*
Winter 2021 *Instructor for CSC 2421H : Graphs, Matrices, and Optimization*
Winter 2021 *Instructor for CSC 263H5 : Data Structures and Analysis*
Fall 2020 *Instructor for CSC 373H5 : Algorithm Design and Analysis*
Winter 2020 *Instructor for CSC 263H5 : Data Structures and Analysis*
Winter 2019 *Instructor for CSC 263H5 : Data Structures and Analysis*
Fall 2018 *Instructor for CSC 2421H : Graphs, Matrices, and Optimization*
Winter 2018 *Instructor for CSC 263H5 : Data Structures and Analysis*
Fall 2017 *Instructor for CSC 2421H : Fast Algorithms via Continuous Methods*

Lecturer, Yale University

Spring 2015 *Lecturer for CPSC 665 : An Algorithmist's toolkit*
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

Winter 2010 *Assistant in Instruction for COS 433: Cryptography*
Fall 2009 *Assistant in Instruction for COS 340: Reasoning About Computation*

Professional Experience

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

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

Summer 2007 **INRIA**, Sophia-Antipolis, France

Research Intern. Supervisor: Frederic Cazals

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