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

## Research Interests

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

2023 - Present Associate Professor (with tenure), Mathematical and Computational Sciences

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

	Associate Professor (with tenure), Department of Computer Science
2017 - 2023	Assistant Professor, Mathematical and Computational Sciences Assistant Professor, Department of Computer Science
2024 – present	Google, Visiting Faculty Researcher
2019 – Present	Vector Institute, Faculty Affiliate
Fall 2023	UC Berkeley, Simons Institute for the Theory of Computing. Visiting Scientist
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 Institute for the Theory of Computing. 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
2025	NSERC Discovery Grant 2025-2030 (CAD 310,000)
2023	Sloan Research Fellowship (USD 75,000)
2023	Frontiers of Science Award at the International Congress on Basic Sciences, 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
2023	MITACS Accelerate Grant (CAD 35,000)
2022	Best Paper Award at FOCS 2022
2022	Ontario Early Researcher Award 2022-27 (CAD 150,000)

- 2021 MITACS Accelerate Grant (CAD 65,000)
- 2018 **NSERC Discovery Grant** 2018-2025 (CAD 243,500)
- 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)
- 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<sup>th</sup> 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

- JACM 2024 Fast Algorithms for  $\ell_p$ -Regression
  - D. Adil, R. Kyng, R. Peng, S. Sachdeva
  - Journal of the ACM, Vol. 71 No. 5, pp. 1–45
- ${\tt CACM~2023~\textit{Almost-Linear-Time~Algorithms~for~Maximum~Flow~and~Minimum-Cost~Flow}}$

L. Chen, R. Kyng. Y. P. Liu, R. Peng, M. P. Gutenberg, S. Sachdeva Communications of the ACM, December 2023, Vol. 66 No. 12, pp. 85–92

- SICOMP 2023 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, Vol. 52 No. 6, pp. 18–85
- 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 Provable ICA with Unknown Gaussian Noise, and Implications for Gaussian Mixtures and Autoen-2015 coders
    - 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.

## Refereed Conference / Workshop Publications

- SODA 2025 Eulerian Graph Sparsification by Effective Resistance Decomposition A. Jambulapati, S. Sachdeva, A. Sidford, K. Tian, Y. Zhao
- FOCS 2024 Almost-Linear Time Algorithms for Decremental Graphs: Min-Cost Flow and More via Duality Jvd. Brand, L. Chen, R. Kyng. Y. P. Liu, S. Meierhans, M. P. Gutenberg, S. Sachdeva
- ICALP 2024 Better Sparsifiers for Directed Eulerian Graphs S. Sachdeva, A. Thudi, Y. Zhao

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- ICALP 2024 Optimal Electrical Oblivious Routing on Expanders C. Florescu, R. Kyng, M. P. Gutenberg, S. Sachdeva
- ITCS 2024 Universal Matrix Sparsifiers and Fast Deterministic Algorithms for Linear Algebra R. Bhattacharjee, G. Dexter, C. Musco, A. Ray, S. Sachdeva, D. P. Woodruff
- ITCS 2024 Electrical Flows for Polylogarithmic Competitive Oblivious Routing G. Goranci, M. Henzinger, H. Räcke, S. Sachdeva, A. R. Sricharan
- SODA 2024 Fast Algorithms for Separable Linear Programs S. Dong, G. Goranci, L. Li, S. Sachdeva, G. Ye
- SODA 2024 Incremental Approximate Maximum Flow on Undirected Graphs in Subpolynomial Update Time Jvd. Brand, L. Chen, R. Kyng. Y. P. Liu, R. Peng, M. P. Gutenberg, S. Sachdeva, A. Sidford
- 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 Communications of 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  $\ell_p$ -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  $\ell_p$ -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  $\ell_p$ -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
  - 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

Invited to Algorithmica Special Issue for Machine Learning

### Theses

- 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–)

Paul Zhang (M.Sc. student, UToronto, 2024-)

Laurel Aquino (MScAC student, UToronto, 2025-)

Jonathan Hsu (MScAC student, UToronto, 2025–)

Sipu Qi (MScAC student, UToronto, 2025–)

Jiongan Mu (MScAC student, UToronto, 2025–)

Yuhe Fan (MScAC student, UToronto, 2024–2025)

Hantang Li (MScAC student, UToronto, 2023–2024)

Anthony Rinaldi (MScAC student, UToronto, 2023–2024)

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, 2022–2024)

Devansh Ranade (UToronto, 2020–2021)

Jack McKinney (UToronto, Summer 2020)

Zejun Yu (UToronto, Summer 2018)

Mentees:

Arun Jambulapati (Fall 2023). Postdoc, U. Michigan.

Yang P. Liu (Summer 2018). Assistant Professor, Carnegie Mellon University.

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

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

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

## Media Coverage

- 2024 Simons Institute Newsletter, Four decades of max flow
- 2022 Quanta Magazine, Researchers Achieve 'Absurdly Fast' Algorithm for Network Flow Quanta Science Podcast, —: Apple, Google, Spotify

### **Talks**

Directed Eulerian Graph Sparsification

- Apr 2025 Data Structures and Optimization for Fast Algorithms Reunion, Simons Institute, Berkeley
- Dec 2024 Theory Seminar, Stanford University
- Oct 2024 7th Eastern Great Lakes (EaGL) Theory of Computation Workshop, U. Buffalo

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  $\ell_p$ -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
	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
	Dagstuhl Seminar, Germany, High Performance Graph Algorithms
	Canada Applied and Industrial Mathematics Society (CAIMS), Toronto University of Waterloo, Department Seminar
	Highlights of Algorithms, Berlin
	Simons Collaboration on Algorithms & Geometry, New York
	TOCA-SV, Stanford University
	TCS Plus Seminar
	Harvard University, Theory of Computation Seminar
Sep 2016	Boston University, Theory Lunch
	Fast Algorithms for Optimization and Learning on Graphs
	Google, New York
	Computer Science Colloquium, Purdue University Department of Computer Science Lecture, University of Toronto, Canada
	Computer Science Seminar, University of Colorado Boulder
1,101 2010	Regression on Graphs – Lipschitz and Isotonic
May 2016	University of Texas Austin, Simons Seminar
	University of Chicago, Scientific and statistical computing seminar
	Lipschitz Learning on Graphs
Nov 2016	Carnegie Mellon University, Theory seminar
	Indian Institute of Technology Bombay, CS department Seminar
Jul 2015	EPFL (École Polytechnique Fédérale de Lausanne) INF department seminar
	Conference on Learning Theory (COLT)
	University of California San Diego, CS department theory seminar
Apr 2015	Yale University, Statistics department seminar
NI 0019	Triangle Removal in Groups
Nov 2013	Simons Institute for Theory of Computing, Real analysis seminar Institute for Advanced Study (IAS) Computer science/discrete mathematics seminar
Apr 2015	
Aug 2012	Generalizations of KKL Theorem and Friedgut's Junta Theorem Simona Institute for Theory of Computing IIC Populator Population workshop
Aug 2015	Simons Institute for Theory of Computing, UC Berkeley, Real analysis workshop
Lun 2012	Hardness for Scheduling Problems
Jun 2015	Conference on Computational Complexity (CCC)
Mar 2013	Near-linear Time Algorithms for Balanced Separator
	Rutgers University, DIMACS/CS theoretical computer science seminar University of Washington, ETP theory connections
May 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:

- 2024 Editor, TheoretiCS
- 2023 SIAM Journal on Computing (SICOMP) FOCS 2023 special issue

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

### Program Committee:

- 2025 Area Chair, Neural Information Processing Systems (NeurIPS) 2025
- 2025 IEEE Foundations of Computer Science (FOCS) 2025
- 2024 Innovations in Theoretical Computer Science (ITCS) 2025
- 2024 Area Chair, Neural Information Processing Systems (NeurIPS) 2024
- 2024 EATCS International Colloquium on Automata, Languages and Programming (ICALP) 2024
- 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
  - $Award\ Committees:$
- 2023 Frontiers of Science Award, Computer Science Stream. ICBS 2024.

#### 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	<b>Toyota Technological Institute</b> , 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