

Algorithms & Randomness Center : Annual Report 2013



2013 in Essence:



Cross-campus research collaborations and initiation of Industry projects as well as industry-inspired research are some of the highlights of 2013. ARC affiliated faculty, postdocs and students continue to garner additional peer recognition, by way of receiving prestigious speaking invitations and research grants (including \$900K for exploratory interdisciplinary research on algorithms for 21st century computing challenges) from the NSF and other Federal agencies.

SCS Chair Lance Fortnow's popular science book made the Best Science Book List for 2013 on Amazon. ARC faculty, postdocs and students continue to publish in top-tier conferences and journals. Various ARC faculty and students have once again won distinguished research awards from Federal and private institutions as well as from the research industry. Hosting of distinguished researchers and expository lecture series continued the tradition from past years.

ARC Director and affiliated faculty thank the staff - Elizabeth Ndongi, Dani Denton (SCS), Annette Rohrs (SOM), and Janet Ziebell (COS) - for the excellent support they provided to the center for yet another year.

Board and Committee Members:

Advisory Board: Jennifer Chayes (Microsoft Research), William Cook (Waterloo), Zvi Galil (Georgia Tech), Ravi Kannan (Microsoft-India), Richard Karp (UC-Berkeley), Richard Lipton (Georgia Tech), and Laszlo Lovasz (Hungarian Academy of Sciences).

Steering Committee: Ton Dieker (ISyE), Vladimir Koltchinskii (Math), Dana Randall (CS), Justin Romberg (ECE), Santosh Vempala (CS), Eric Vigoda (CS).

Student Fellowship Committee: This is the committee in charge of evaluating the ARC student fellowship applications each Fall and Spring semester. Beginning Fall 2012, Santosh Vempala was appointed as the Chair of the committee, with the other members being Nina Balcan (CS), Gregory Blekherman (Math), Sasha Boldyreva (CS), Santanu Dey (ISyE), and David Goldberg (ISyE).

RESEARCH ACTIVITIES

Research Discussions

The ThinkTank Aspect:

An important objective of ARC is to provide consulting and otherwise help on all matters algorithmic! To facilitate this, ARC hosts research lunches featuring guests from various branches of the Sciences and the Engineering on a regular basis. The guest lecturer gives a brief 15 minute presentation after which the discussion is typically interactive with an intent to model, analyze and help solve problems from a rigorous and algorithmic perspective.

While the participation is by invitation, prospective guests are highly encouraged and welcomed to write to the ARC Director for a visit. See <http://www.arc.gatech.edu/???> for some recent examples.

Research Projects

Graduate Students

Since Spring 2008, in all 55 students from various schools have received up to 50% RA funding by ARC, matched by the Ph.D. advisors. The continuing support of competitive research proposals from the graduate students resulted in the following winners for Spring 2014: (Lists of previous winners can be found on the ARC website.)

[Gustavo Angulo](#), (Advisors : Shabbir Ahmed and Santanu S. Dey, ISYE) “A polyhedral study of all-different polytopes”;

[Spencer Backman](#), (Advisor: Matt Baker, Math) "A Complex Valued Hypergraph Laplacian”;

[Andreas Galanis](#), (Advisor: Eric Vigoda, CS) "Hardness of Approximately Counting Colorings”;

[Sara Krehbiel](#), (Advisor: Chris Peikert, CS) "Paying for Privacy”;

[Robert Krone](#), (Advisor: Anton Leykin, Math) “Algorithms for Equivariant Ideals and Varieties”;

[Andrew Massimino](#), (Advisor: Mark Davenport) “Constrained Adaptive Sensing”;



In 2013, concrete research projects were initiated with supply chain and retail industries, and the teams exchanged mutual visits.

Examples:

Guest: Symbotic, LLC, Woburn, Massachusetts

Guest: Macy’s Systems & Technology, Duluth, GA
(See section on Industry Collaboration below.)

Attempts to engage in potential projects with the City of Atlanta Mayor’s office, involving infrastructure repairs, maintenance, sustainability etc., are in progress.

[Sarah Miracle](#), (Advisor: Dana Randall, CS) “Markov Chains to Model Segregation and Biased Surfaces”;

[Aurko Roy](#), (Advisor: Santosh Vempala CS and ISYE) "Learning a Polytope".

ARC-RIM Collaboration

Collaboration of Tetali and Frank Dellaert (Interactive Computing faculty and RIM member) with their students Ioannis Panageas and Yong-Dian Yang, along with a former postdoc Doru Balcan resulted in a publication in the 2013 International Robotics and Systems conference IROS: “Support-theoretic subgraph preconditioners for large-scale SLAM.”

Undergraduate Involvement

CS Undergrads and programming experts Kyle Davis, and Daniel Hull have worked with Christensen and Tetali as well as Tetali’s graduate student Arindam Khan in competing and winning the annual KUKA palletizing programming competition.

RESEARCH HIGHLIGHTS



Conference Publications

ARC faculty, postdocs, and students show strong presence in competitive, top-level international conferences such as, CRYPTO, FOCS, RANDOM-APPROX, SODA, and STOC (**GT Co-authors** highlighted below):

SODA 2013:

“Towards Polynomial Simplex-Like Algorithms for Market Equilibria,” **Jugal Garg, Ruta Mehta**, Milind Sohoni and Nisheeth Vishnoi.

“Beating the Direct Sum Theorem in Communication Complexity with Implications for Sketching,” **Marco Molinaro**, David Woodruff and Grigory Yaroslavtsev.

“Mixing Times of Self-Organizing Lists and Biased Permutations,” **Prateek Bhakta, Sarah Miracle, Dana Randall** and **Amanda Pascoe Streib**.

“Finding Endogenously Formed Communities,” **Maria-Florina Balcan**, Christian Borgs, Mark Braverman, Jennifer Chayes and Shanghua Teng.

STOC 2013:

“Classical Hardness of Learning with Errors,” Zvika Brakerski, Adeline Langlois, **Chris Peikert**, Oded Regev, and Damien Stehle.

“The Approximate Rank of a Matrix and its Algorithmic Applications,” Noga Alon, Troy Lee, Adi Shraibman, and **Santosh Vempala**.

“Statistical Algorithms and a Lower Bound for Detecting Planted Cliques,” Vitaly Feldman, Elena Grigorescu, Lev Reyzin, **Santosh Vempala**, and **Ying Xiao**.

CRYPTO 2013:

“Practical Bootstrapping in Quasilinear time,” **Jacob Alperin-Sheriff** and **Chris Peikert**.

“Hardness of SIS and LWE with Small Parameters,” Daniele Micciancio and **Chris Peikert**.

RANDOM-APPROX 2013:

“Improved Bounds on the Phase Transition for the Hard-Core Model in 2-Dimensions,” Juan Vera, **Eric Vigoda** and **Linji Yang**.

“Phase Coexistence and Slow Mixing for the Hard-Core Model on Z^2 ,” Antonio Blanca, David Galvin, **Dana Randall** and **Prasad Tetali**.

FOCS 2013:

“Common Information and Unique Disjointness,” **Gabor Braun** and **Sebastian Pokutta**.

“The Complexity of Approximating Vertex Expansion,” **Anand Louis**, Prasad Raghavendra and **Santosh Vempala**.

RESEARCH HIGHLIGHTS (continued)



Honors & Awards

SCS Faculty Nina Balcan and GT ACO PhD program alum Nayantara Bhatnagar, University of Delaware (student of Dana Randall and Eric Vigoda), were recipients of the 2013 Alfred P. Sloan Foundation Fellowship.

Ton Dieker has been awarded an IBM Faculty Award, a competitive worldwide award intended to foster collaboration between researchers at leading universities worldwide and those in IBM research, development and services organizations.

SCS Faculty Chris Peikert received the College of Computing Junior Faculty Research Award for 2013. Peikert also recently won the Google Research Award, and taught a 5-day summer school on Lattice-Based Cryptography at Bonn University in Germany.

Dana Randall was appointed the Chair of the Institute for Mathematics & Applications (IMA) Board of Governors. Dana Randall also gave an NSF CISE Distinguished Lecture in May 2013 on "Sampling, Random Structures and Phase Transitions," all topics of much interest to ARC.

Lance Fortnow published his popular science book *"The Golden Ticket: P, NP and the Search for the Impossible"* (Princeton University Press). The book was chosen as one of Amazon's Best Science Books for 2013 and honorable mention for the 2013 PROSE Award for Popular Science & Popular Mathematics.

Also in 2013, Fortnow gave the EATCS Plenary Lecture at Computability in Europe Conference, Milan, Italy; Plenary Lecture at Clay Research Conference, Cambridge, England; Stony Brook University Computer Science Distinguished Lecturer.

Graduate Students

In recognition of her continuing excellent work, Sarah Miracle was awarded a fellowship of \$7,500 from the Achievement Rewards for Academic Scientists (ARCS) program for a *second time!*

The ARCS Scholars Award recognizes outstanding doctoral students who have a record of past achievement and who show exceptional promise of making a significant contribution to the worldwide advancement of science and technology.

First year ACO student Sarah Cannon was one of two recipients of the prestigious Claire Boothe Luce Fellowships at Georgia Tech, for her previous and proposed work based on self-assembly models, bridging algorithms with nanotechnology.

EDUCATION

Besides supporting competitive research projects put forth by graduate students by way of ARC student fellowships each term, ARC hosts expository lecture series as well as tutorials on topics of current interest. Georgia Tech alum Adam Marcus (ACO Ph.D. 2008, student of Prasad Tetali) gave lectures on campus in December 2013 on his breakthrough work, with Daniel Spielman (Yale University) and Nikhil Srivastava (Microsoft Research), on *Interlacing Polynomials and the resolutions of the Kadison-Singer conjecture.* Several ARC affiliated faculty in addition delivered expository lectures on their research at various national and international venues.

Lectures

Each of the following visitors gave a series of lectures on exciting frontier research topics.

- 1) Sanjeev Arora
- 2) Adam Marcus
- 3) Jennifer Chayes
- 4) Gil Kalai
- 5) Shafi Goldwasser
- 6) Avrim Blum
- 7) Ravi Kannan



1)



2)



3)



4)



5)



6)



7)

Reading groups and courses

Keeping up the tradition, ARC-affiliated postdocs offered a joint course on a frontier research topic during **Spring 2013**: *Advanced Topics in Algorithmic Game Theory* by Jugal Garg, Ruta Mehta (ARC and NSF-funded CS postdocs), and Georgios Piliouras (ECE postdoc).

Student Seminars

ACO, ARC and the School of ISyE have been cost sharing in funding the pizza-lunch student seminar series organized and hosted by the ACO Ph.D. students for the past few years. The speakers include on-campus students, postdocs, faculty, as well as visiting researchers. The lectures are aimed at non-specialists and have been a very effective tool in the ongoing learning process of the relevant community.

Collaborations Across Campus

ARC Director Tetali led a team of 10 PIs in securing 3 NSF *Early-concept Grants for Exploratory Research* (EAGER), each an award of \$300K and lasting two years, starting March 1, 2014. This collaboration brings together faculty across campus, in particular from the Schools of CS, School of Interactive Computing from the College of Computing, and the School of ECE and School of ISYE from the College of Engineering, and the School of Math from the College of Sciences. The titles and the corresponding PIs are listed below.

EAGER: Discrete Optimization Algorithms for 21st Century Challenges

EAGER: Physical Flow and other Industrial Challenges

EAGER: Convex Optimization Algorithms for 21st Century Challenges

PIs (Georgia Tech and Carnegie Mellon University):

College of Computing: Nina Balcan and Santosh Vempala from SCS, Henrik Christensen from SIC

College of Engineering: Santanu Dey, George Nemhauser, Arkadi Nemirovski, and Sebastian Pokutta from ISyE, and Justin Romberg from ECE

College of Science: Vladimir Koltchinskii and Prasad Tetali from SOM.

CMU: Avrim Blum (CS).

S. Dey



A. Blum



N. Balcan



G. Nemhauser



H. Christensen



P. Tetali



S. Pokutta



V. Koltchinskii



A. Nemirovsky



S. Vempala



J. Romberg



Industry Collaboration



Symbotic LLC - Intelligent Supply Network Automation

ARC and RIM directors Tetali and Christensen have been collaborating with the supply chain automation company Symbotic in Woburn, MA, since 2012. Inspired by this association, more recently Tetali with the help of the ARC postdocs Jugal Garg, Ruta Mehta and the CS students Kyle Davis and Daniel Hull have been developing fast algorithms and heuristics for warehouse mobile bot routing.



Macy's online order fulfillment

In an ongoing industry collaboration with Macy's Systems and Technology, Pokutta and Tetali developed an online order fulfillment algorithm that determines (near) optimal shipping locations for multi-item orders under strong real-time requirements. The underlying combinatorial problem is theoretically hard so that a generic efficient solution is unlikely to exist. The algorithm consists of various simple and extremely fast heuristics and meta-heuristics which are intelligently combined to ensure execution times in the order of milliseconds while maintaining a solution quality which is very close to the optimal one.

Collaboration with External Research Institutes

IMA Institute for Mathematics
and its Applications



The Institute for Mathematics & Applications (IMA)

ARC Director Tetali headed a team of 6 organizers who put together a year-long program at the IMA for 2014-15. One of the workshops will be hosted on GT campus during March 2015.

Discrete mathematics has been flourishing in the last couple of decades and many of its subareas (particularly, combinatorics) have become central areas in the mathematics community, attracting the attention of highly respected researchers from other disciplines. Program workshops will span frontier topics of research in discrete mathematics (including combinatorics and optimization) and probability throughout the year.

One of the program's specific goals will be to use this forum to make the state-of-the-art more accessible to a broader audience. Particularly through the planning of tutorial lectures, participation by graduate students of various mathematical backgrounds and postdoctoral researchers will be a priority. It would be of great benefit to gather leading researchers in these various sub-fields to facilitate an exchange of knowledge and also to identify new research directions so as to expand the horizons. We thus expect a thematic year of this nature to have a lasting impact on the future of the subject.



Special Year Workshops:

1. 9/8-12/2014 : *Probabilistic and Extremal Combinatorics*
2. 9/29-10/3/2014 : *Additive and Analytic Combinatorics*
3. 11/10-14/2014 : *Geometric and Enumerative Combinatorics*
4. 2/23-27/2015 : *Convex Optimization: Theory and Applications*
5. 3/16-20/2015 : ***Workshop on the Power of Randomness in Computation (to be hosted at Georgia Tech)***
6. 4/13-17/2015 : *Information Theory and Concentration Phenomena*
7. 5/18-22/2015 : *Graphical Models, Statistical Inference, and Algorithms (GRAMSIA)*
8. 6/22-26/2015 : *Analytical Tools in Probability and Applications (at the Euler Institute, St. Petersburg, Russia)*

High Profile Speakers

ARC 6 Annual Event (November 5, 2013)

Keynote Speaker:

Shafi Goldwasser, MIT

Georgia Tech Speakers:

Matt Baker, Math

Ozlem Ergun, ISyE

Lance Fortnow, CS

Georgia Tech Algorithms & Mathematics Overview

ARC6

Nov. 5, 2013 • 1 pm - 4 pm
Klaus 1116

Keynote Speaker

Shafi Goldwasser
MIT and Weizmann Institute
Title: "The Cryptographic Lens"

Schedule

12:00 pm Lunch

1:00 pm Welcome and Introduction

1:00 pm **Matt Baker, Mathematics**
Georgia Institute of Technology
"The P vs NP Problem: The Matrix Test Theorem"

1:30 pm **Ozlem Ergun, ISyE**
Georgia Institute of Technology
"The P vs NP Problem: The Matrix Test Theorem"

2:00 pm **Lance Fortnow, Computer Science**
Georgia Institute of Technology
"The P vs NP Problem: The Matrix Test Theorem"

2:30 pm Break and Refreshments

3:00 pm **SCS / GTCS / ARC Distinguished Lecture**
Shafi Goldwasser
MIT and Weizmann Institute
"The Cryptographic Lens"

SCS Distinguished Lecture by

Jennifer Chayes, Microsoft Research

Distinguished Scientist and Managing Director of MSR-NE and MSR-NYC, Jennifer Chayes, spoke about *the age of networks*, focusing on modeling and analyzing various networks -- social, economic, technological as well as gene regulatory networks, focusing in particular on algorithms for inferring networks of relevance to cancer genomics.

Georgia Tech School of Computer Science

SCS Distinguished Lecture

Age of Networks

WHO:
Jennifer Tour Chayes
Distinguished Scientist and Managing Director,
Microsoft Research New England

WHEN & WHERE:
November 26, 2013 @ 11 a.m.
Cloud Advanced Computing Building
1116 East and West

PRESENTED BY:
The School of Computer Science

ABSTRACT:
Everywhere we turn, we find that networks can be used to describe almost anything. In the technology, we see the Internet, the World Wide Web, and a variety of online social networks. In economics, we see sprawling transportation, supply, and distribution networks. In biology, we find dense signaling networks and gene regulatory networks. In social networks, we are beginning to understand the structure of gene regulatory networks, and the structure of social networks. In general, networks are everywhere. In this talk, I will talk about general algorithms for inferring networks, and how these algorithms are being used to understand the structure of gene regulatory networks, and the structure of social networks. I will also talk about how these algorithms are being used to understand the structure of gene regulatory networks, and the structure of social networks.

Distinguished Lecture by

Michael Rabin, Harvard University

Turing Award Winner Michael Rabin gave two lectures describing his recent breakthrough work with Silvio Micali on collusion prevention in Vickrey auctions and vote tallying and public verification in Electronic voting.

Georgia Tech Algorithms & Mathematics Overview

ARC Talks: Michael O. Rabin

Harvard University, Columbia University

March 10-11, 2014

Michael O. Rabin
Harvard University, Columbia University

March 10, 2014, 3:30-4:30pm
Lecturer: Klaus 1116

Title: Practically Efficient ZKPs for Prover-Deleter Collusion in Auctions

Abstract: It is important mechanism for sealed bid auctions developed by Vickrey and awarded by a Nobel Prize. The highest bidder gets the item and pays the second highest bid value. Vickrey proved that for these auctions the best strategy for a participant is to bid his private true value for the item. Despite this advantage, sealed price auctions were widely used because they are subject to collusion of bidders. Employing novel cryptography we show that collusion can be eliminated via auction. A long standing open problem. The talk will be generally accessible. Joint work with Silvio Micali.

March 11, 2014, 3:00-4:00pm
Lecturer: MHC 102 A & B

Title: Electronic Voting Using The Split Value Representation

Abstract: We present an e-voting system wherein votes are represented by the vote-holding center in the form $(COM_i) = (COM_i, COM_i)$, $vote_i = vote_i$ for $i = 1, \dots, n$. The voter gets a proper receipt for (COM_i) . His actual vote remains secret and he cannot be coerced to cast a specified vote. Note that, the receipt consists of individual votes (with generating and issuing a publicly verifiable proof of correctness of all received correct receipts). This presentation will be generally accessible. Joint work with Ron Rubinfeld.

Continuing the Tradition



Monday, April 8, 2013
ARC Distinguished Lecture
Klaus 1116

3:00 pm
Avrim Blum
(CMU)
Algorithmic Pricing

Abstract:
Pricing and allocating goods to buyers with complex preferences in order to maximize some desired objective (e.g., social welfare or profit) is a central problem in Algorithmic Mechanism Design.

In this talk I will discuss some particularly simple algorithms that are able to achieve surprisingly strong guarantees for a range of problems of this type. As one example, for the problem of pricing resources, modeled as goods having an increasing marginal extraction cost to the seller, a simple approach of pricing the i th unit of each good at a value equal to the anticipated extraction cost of the $2i$ th unit gives a constant-factor approximation to social welfare for a wide range of cost curves and for arbitrary buyer valuation functions. I will also discuss simple algorithms with good approximation guarantees for revenue, as well as settings having an opposite character to resources, namely having economies of scale or decreasing marginal costs to the seller.

Tuesday, April 9, 2013
Klaus 1116 E & W

9:15 am - Breakfast

9:50 am - Introduction by Zvi Galil
(CoC Dean)

10:00 am - Yael Kalai
(Microsoft Research)
Efficient Error-Resilient Interactive Protocols

11:15 am - Raghu Meka
(Rutgers and IAS)
Beating the Union Bound via Geometric Techniques

12:15 pm - Lunch

1:30 pm - Ankur Moitra
(Princeton and IAS)
An Information Complexity Approach to Extended Formulations

2:45 pm - Thomas Rothvoss
(MIT)
Approximating Bin Packing Within $O(\log OPT \cdot \log \log OPT)$ bins

ARC Theory Day 2013

(April 9, 2013)

ARC Theory Day 2014

(April 25, 2014)

Featuring :

Eric Allender (Rutgers University)

Julia Chuzhoy (Toyota Technical Institute, Chicago)

David Steurer (Cornell University)

Nike Sun (Stanford University)

Nisheeth Vishnoi (Microsoft-India, EPFL-Lausanne, Switzerland)

ARC-RIM Industry Day on Logistics and Material Handling Optimization

(May 4, 2013)

ARC-IDH-RIM Industry Day on Data Science

(April 18, 2014)

Grants and External Support:



1. **NSF EAGERS:** \$900K (Starting March 1, 2014)
2. **Symbotic LLC:** \$30K GT Foundation Gift (October 2013)
3. **Macy's Systems & Technology:** \$56K (through GTRC)

Budget

CoC contributed \$50K, and COE as well as COS contributed \$35K for the current fiscal year. Richard Fujimoto, Director of IDH, contributed \$15K to help support the Industry Day and the Theory Day, the annual events that ARC hosts.

Self Assessment

NSF EAGER grants will facilitate concrete collaborations across campus, between researchers in algorithms, machine learning, combinatorial and convex optimization, statistics, signal processing and robotics. ARC faculty plan on leveraging this to take another shot at the NSF Expeditions in Computing competition in 2015. Pertinent ARC faculty see many opportunities for collaborations with IDH and other centers in this important area, which inspired the upcoming ARC-IDH-RIM Industry Day.

Moving Forward

The emerging discipline of *Data Science* offers natural opportunities for ARC faculty and students to strengthen existing and forge new collaborations across campus and beyond. ARC faculty see opportunities for collaborations with the IDH and other centers in this important area, which inspired the theme for the upcoming ARC-IDH-RIM Industry Day.

Tetali is completing his third year as the director of ARC, and will be rotating out in 2014. Advance Professor Dana Randall will assume the responsibility starting May 15, 2014.

“I am delighted to be taking over as director of the Algorithms and Randomness Center later this spring. ARC has transformed research in algorithms and randomness at Georgia Tech by building bridges across units and centers, engaging in new industrial collaborations, providing alternative perspectives on projects across the campus, and engaging students and postdoctoral researchers in novel and impactful ways. We owe much gratitude to the founding ARC directors, Santosh Vempala and Prasad Tetali, for their excellent leadership and boundless energy, as well as the countless faculty and students who have contributed to the center's success. I look forward to working with many of them as ARC moves forward.”

-- **Dana Randall.**

