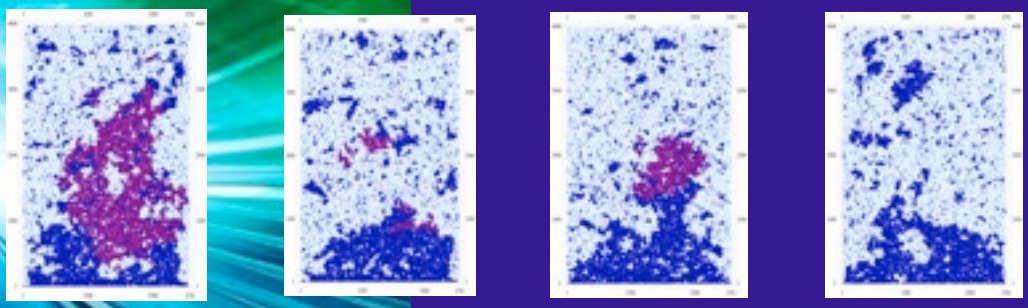
Algorithms & Randomness Center : Annual Report 2012



Director's Summary:

Building on the solid foundation laid by the founding director (Santosh Vempala), the current director and ARC faculty have made a stride in increasing the national and global visibility of ARC. The slew of new initiatives include (i) organizing thematic focus year workshops and conferences on topics of frontier research, (ii) launching the inaugural (and annual) ARC Theory Day as well as the ARC-RIM Industry Day, (iii) hosting academic and industrial research visitors on a short-term basis, and (iv) contributing to the educational mission of Georgia Tech by incorporating tutorial-style lectures into each of the above research initiatives. Collaborations across campus and nation-wide culminated in a highly competitive (and pending) NSF Expeditions proposal on *Algorithmic Challenges of 21st Century* involving 9 faculty from 5 schools on campus, and an additional 9 top researchers from other universities as well as Microsoft Research.

Board and Committee Members:

Distinguished Scientist and Managing Director **Jennifer Chayes** of Microsoft Research-New England as well as that of the newly created Microsoft Research-New York has been appointed as a new member on the ARC Advisory Board.

In an attempt to broaden the scope and involvement, and help plan thematic years and other activities, a newly appointed steering committee has been formed:

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

Student Fellowship Committee: This committee in charge of evaluating the ARC student fellowship applications each Fall and Spring semester. In the past it has been chaired by P. Tetali (2008-11) and T. Dieker (ISyE, 2011-12) and has had a rotating ensemble of ARC faculty. S.Vempala is the current chair, with the other members being N. Balcan (CS), G. Blekherman (Math), S. Boldyreva (CS), Santanu Dey (ISyE), and D. 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/content/research as well as the recently compiled ARC Self-Assessment document for additional information.

Recent Examples:

Guest: Eric Gilbert, School of IC, Ga Tech

Guest: Sean Webb, Enterpreneur, Adamas Inc. Charlotte, NC

Guest: Anton Kleywegt, School of IC, Ga Tech

Guest: Josh Weitz, School of Biology, Ga Tech

Past guests include: Jeff Skolnick (Biology), Henrik Christensen (Interactive Computing), Steve McLaughlin (ECE), Justin Romberg (ECE), David Bader (CSE), Mostafa Ammar (CS) etc.

Research Collaborations

ARC-RIM Collaboration

F. Dellaert (Interactive Computing faculty and RIM member) and P. Tetali have been collaborating, with the help of their graduate students, on subgraph preconditioners for simultaneous localization and mapping, a challenging problem inspired by autonomous mobile robots. Current progress is being reported in : "*Support-theoretic subgraph preconditioners for large-scale SLAM*."

Undergraduate Involvement

CS Undergrads and programming experts Kyle Davis, Zhongtian Zhang, and more recently Daniel Hull have been helping the directors of ARC and RIM in tackling challenging 3-D bin and vehicle routing problems, arising from robotics-based supply chain industry applications. ACO graduate students Pushkar Tripathi and Arindam Khan have helped mentor the undergraduates and trained them with the relevant algorithmic theory.

More recently the ARC postdocs Jugal Garg and Ruta Mehta have joined in the efforts to tackle these challenging theoretical and practical problems, inspired by the physical flow problems from the real world.

Research Projects by Graduate Students

Since Spring 2008, in all 47 students from various schools have received 50% RA funding by ARC, typically matched by the Ph.D. advisors.

The continuing support of competitive research proposals from the graduate students resulted in the following winners during 2012-13: (Lists of previous winners can be found on the ARC website.)

During the ARC annual events, the students supported by ARC make poster presentations.

Spring 2013

1. A. Guzman (advisor: A. Nemirovski, ISyE): "A new model for image regularization"
2. C-H. Liu (advisor: R. Thomas, Math): "Well-quasi-ordering graphs by the immersion relation"
3. D. Moran (advisor: S. Dey): "On cutting planes for convex mixed-integer programs"
4. I. Panageas (advisors: P. Tetali and F. Dellaert):"Preconditioning in the non-Laplacian case"
5. L. Xin (advisors: D. Goldberg and A. Shapiro): "Moment convergence rate in stochastic optimization."

Fall 2012

1. P. Bhakta (advisor: D. Randall): "Mixing times of the Schelling segregation model and biased permutations"
2. A. Khan (mentors: P. Tetali and H. Christensen): "Algorithms for 3-D geometric bin packing"
3. A. Louis (mentors: P. Tetali and S. Vempala): "A new approach towards graph coloring"
4. F. Shokrieh (advisor: M. Baker): "Random basis algorithm for regular matorids."

Spring 2012

1. K. Chandrasekaran (advisor: S. Vempala): "The complexity of the cutting plane method"
2. N. Chenette (advisor: S. Boldyreva): "Efficient fuzzy searchable encryption"
3. A. Galanis (advisor: E. Vigoda): "Phase transitions in the complexity of counting"
4. J. Yu (advisor: O. Ergun): "Atomic congestion games with taxes on resources."

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. Examples include Frank Vallentin's minicourse on *Modern Applications of Semidefinite Programs* (September 26 -- October 7, 2011), Amin Coja-Oghlan's lectures on *Random Constraint Satisfaction Problems* (February 25 -- March 8, 2012), and tutorial lectures embedded in the workshops (March and June 2012). Several ARC affiliated faculty in addition deliver expository lectures on their research at various national and international venues.

Lectures

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

1. Frank Vallentin, Professor, Delft University of Technology, The Netherlands
2. Noga Alon (Israel Prize winner), Professor, Tel Aviv University
3. Persi Diaconis (MacArthur Fellow, Fellow of AAAS), Professor, Stanford University
4. Fredrich Eisenbrand, Chair of Discrete Optimization, Ecole Polytechnique Federale de Lausanne
5. Ravi Kannan (Knuth Prize winner), Microsoft Research, Bangalore, India
6. Amin Coja-Oghlan, Professor, Goethe University, Frankfurt
7. Gil Kalai, (Rothschild Prize winner), Professor, Hebrew University and Yale University.

Reading groups, seminars, and courses

ARC postdocs as well as CS and SoM postdocs have offered joint courses during the past couple of years: **Spring 2012**: *Discrete Fourier Analysis* by Will Perkins (NSF Postdoc, SoM), Elena Grigorescu and Lev Reyzin (postdocs supported by ARC, SCS and Simons Foundation).

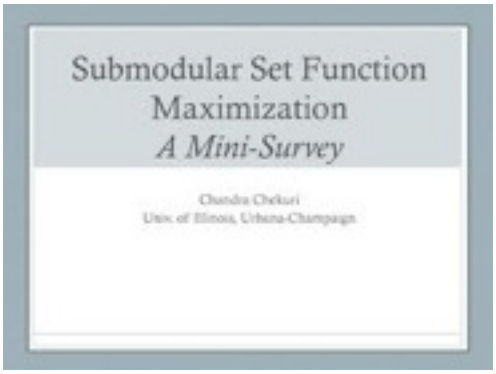
Spring 2013: *Advanced Topics in Algorithmic Game Theory* by Jugal Garg, Ruta Mehta (ARC and NSF-funded postdocs), and Georgios Piliouras (ECE postdoc).

High-dimensional phenomena in Statistics and Machine Learning Seminar: ARC faculty Nina Balcan (CS), Vladimir Koltchinskii (SoM), Justin Romberg (ECE) and Karim Lounici (SoM) co-organize an ongoing reading and research seminar.

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.

Workshops and Outreach

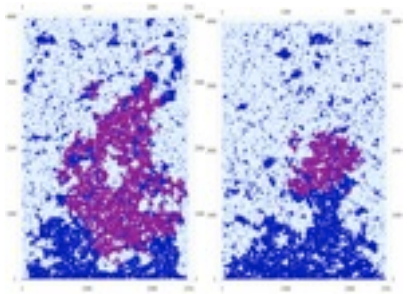


Modern Aspects of Submodularity (March 19-22, 2012)

Organizers: Shabbir Ahmed (ISyE), **Nina Balcan** (CS), **Satoru Iwata** (Kyoto), and **Prasad Tetali**

This workshop brought together the very top researchers in the topic from academia as well as the industry (Google, IBM, Microsoft), and was funded by Georgia Tech, the Institute of Mathematics and Applications (IMA, Minnesota), Microsoft Research, and the Yandex Corporate (Russia). **Day 1 included 6 hours of tutorial lectures by three leading experts**.

see details: http://www.arc.gatech.edu/events/arc-submodularity-workshop

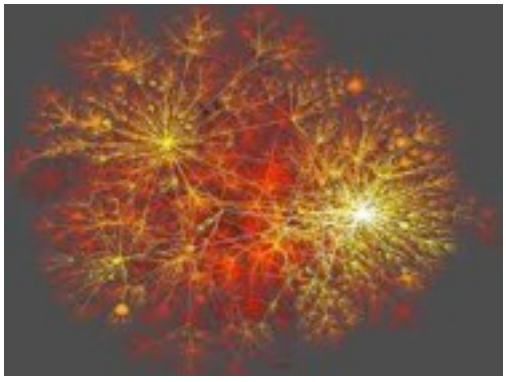


Computation and Phase Transitions (June 4-8, 2012)

Organizers: Dana Randall (CS), **Prasad Tetali,** and **Eric Vigoda** (CS)

This workshop brought together researchers from CS, Statistical Physics, Probability and Statistics. It was funded by the NSF and Georgia Tech.

see details at http://www.arc.gatech.edu/events/computation-and-phase-transitions-workshop



Network Topology and Economics (November 12-14, 2012)

Organizers: Constantine Dovrolis (CS), **Alex Fabrikant** (Google Research), **Michael Shapira** (Hebrew University), and **Prasad Tetali**

The workshop brought together the communities of Network Economics and Internet Topology. It was primarily funded by a grant from the Russian search engine company Yandex Corporate, along with support from ARC and IDH. see details at http://www.arc.gatech.edu/events/arc-yandex-workshop-internet-topology-and-economics

ARC Theory Day (November 11, 2011)

Speakers included the IAS Permanent member Avi Wigderson, and four younger award-winning paper authors from theoretical CS community: Thomas Hansen (Germany), Alexandr Madry (Microsoft Research), Mohit Singh (McGill University), and Ryan Williams (Stanford University).

All lectures were video-taped and archived and made available through the GaTech library resources. see details at http://www.arc.gatech.edu/events/arc-theory-day-1

Theory Day II is being planned for April 9, 2013.

ARC-RIM Industry Day (May 4, 2012)

The objective is in bringing together leading researchers/developers from industry with leading researchers from academia to discuss challenges, opportunities and new trends in logistics, physical material flow, optimization, and related algorithms.

See details at http://robotics.gatech.edu/content/arc-rim-industry-day

Industry Day II is being planned for April 25, 2013.

ARC 5 Annual Day

Noga Alon is a Baumritter Professor of Mathematics and Computer Science in Tel Aviv University, Israel. He won the Israel Prize (2008) and the EMET prize (2001). A more complete list of his accomplishments is at: http://www.tau.ac.il/~nogaa/

Persi Diaconis is the Mary Sunseri Professor at Stanford in the Department of Statistics and Professor of Mathematics. He is a MacArthur fellow and his full list of achievements and awards can be found at : http://www-stat.stanford.edu/~cgates/PERSI/cv.html

In line with the previous ARC annual event has attracted a large audience. This year's event featured two very distinguished, highly recognized scientists: Noga Alon and Persi Diaconis.

Their lectures were accompanied by talks on recent technical contributions by three Georgia Tech faculty: Grigory Blekherman (Math), Frank Dellaert (IC), and Justin Romberg (ECE).

ARC Student Fellowship winners made presentations over a catered lunch session.

Grants and External Support

The $1.08 million 3-year NSF grant secured by the ARC faculty Randall, Tetali, Vempala, and Vigoda came to a successful completion by September 2012. Besides this grant, the following industrial sponsors together contributed about $50K towards various workshops hosted during 2012: Yandex Corporate (Russia), Microsoft Research, and Google Research.
In addition, the **Institute for Mathematics and Applications (IMA),** Minnesota, and the Schools of Mathematics and ISyE, as well as the Institute for Data and High-Performance Computing (IDH) on campus, have played a role in supporting some of the workshops that ARC has hosted during 2012.

Individual Grants

Various ARC faculty have received the following funding during 2012; the list is by no means exhaustive:

1. Ton Dieker (NSF CAREER: 2013-2017): "Stochastic processes in high-dimensions: from asymptotic analysis to algorithms," $400K.

2. Lance Fortnow (NSF grant: 2012-2015): "Bounding rationality by computational complexity," $152K.

3. Vladimir Koltchinskii (NSF grant: 2012-2015): "Complexity Penalization in High-Dimensional Matrix Estimation Problems," $300K.

4. Arkadi Nemirovsky (NSF grant: 2012-2015; joint with Co-PI Alex Shapiro): "Design of efficient saddle point algorithms for large-scale/complex geometry convex optimization," $450K.

5. Dana Randall (NSF grant: 2012-2015): "Markov chain algorithms for problems from computer science, statistical physics and algorithms," $280K.

6. Jeff Shamma (ARO/MURI grant: 2012-2017; joint with A. Jadbabaie (PI), UPenn, and others): "Evolution of cultural norms and dynamics of socio-political change," $500K (out of a total of $6.25 Million over 5 years.)

7. Robin Thomas (NSF grant: 2012-2017): "Graph Structure Theory and Applications to Algorithms," $585K.

8. Vijay Vazirani: (NSF grant: 2012-2016; joint with John Ledyard (CalTech Economist)): $600K (out of a total of $700K).

9. Santosh Vempala: (NSF grant: 2012-2015): "Fundamental High-Dimensional Algorithms based on Convex Geometry and Spectral Methods," $420K.

10. Eric Vigoda: (NSF grant: 2012-2015): "Phase Transitions in Approximate Counting Problems," $383K.

Institute Support

Following presentations by the ARC director during the past year, the Deans of CoC, CoE and CoS as well as the EVPR have expressed strong enthusiasm for supporting ARC for the next cycle of 5 years (2012-2017), subject to a successful review after two years (during 2014). Pledges include $50K (CoC), $35K (CoE), and $35K (CoS) for FY 2013 and FY 2014. EVPR's office contributed $50K for FY 2013 and is currently considering ARC's budget request for FY 2014.

NSF Expeditions: Collaborative Proposal

Algorithms for 21st Century Challenges

A team of Georgia Tech faculty in collaboration with several distinguished external scientists made a concerted effort in putting together a very strong proposal for the NSF Expeditions solicitation. The proposal is currently under review.

GOALS & CHALLENGES:

The goal is to tackle algorithmic challenges of the current century. The project proposes to identify gaps between several well-identified challenges and the state-of-the-art in theory and practice, and develop algorithmic techniques to bridge these gaps, via the following focus topics: Integer Programming, Convex Optimization, Matrix Estimation and Analysis, Phase Transitions in Random Structures & Algorithms and (real world) Industry Challenges. Statistical learning theory, machine learning algorithms and randomness (in instances and in algorithm design) play a fundamental cross-cutting role in all of the above topics; a further opportunity and challenge is to develop, analyze, and harness methods that optimize with provable accuracies, and provide problem-specific guarantees. The research outlined in the proposal is expected to yield novel and fundamental optimization and algorithmic techniques with far-reaching impact.

PERSONNEL:

To address these challenges a diverse team was assembled whose research expertise ranges from different aspects of theory to various application domains, with several researchers experienced in both ends of the spectrum. The team consists of Prasad Tetali (PI), and Co-PIs Henrik Christensen (IC), Vladimir Koltchinskii (SOM), George Nemhauser (ISyE), Arkadi Nemirovski (ISyE) Dana Randall (CS), Justin Romberg (ECE), Santosh Vempala (CS) from **Georgia Tech**.
External Co-PIs include: Avrim Blum (CS) and Alan Frieze (Math) from **Carnegie Mellon University**, Pankaj Agarwal (CS) from **Duke University**, Vojtech Rodl (Math) from **Emory University**, and Shang-Hua Teng (CS) from **University of Southern California.**
Senior Personnel on the proposal include distinguished scientists, Noga Alon (**Tel Aviv University),** Bill Cook (**University of Pittsburgh),** Jennifer Chayes (Director of **Microsoft Research - New England and New York City**), Ravi Kannan (**Microsoft Research - Bangalore**), Joel Spencer (**Courant Institute, New York University**), as well as Andrea Lawrence (CS) from **Spelman College.**

EDUCATIONAL AND PROFESSIONAL TRAINING COMPONENT:

The team also proposed to offer a Masters degree in advanced and applied aspects of Algorithms and training a new generation of students with an interdisciplinary skill set. Mentoring students at the Spelman college in placing them in the Georgia Tech College of Computing Masters program is an important first step in what the team hopes to be transformative in bringing some of the local colleges up-to-speed.

ENDORSEMENTS:

The proposal was enthusiastically endorsed with letters of support by visionaries and influential scientists, including Emmanuel Candes (Stanford), Richard Karp (UC Berkeley, Simons Institute), Craig Mundie (Microsoft Research), Fadil Santosa (IMA Director), and Sebastian Thrun (Stanford and Google Research).

ADDITIONAL HIGHLIGHTS and RECOGNITIONS

New Recruits and Inductees:

Jugal Garg and Ruta Mehta have been hired as ARC postdocs, after they have successfully defended their dissertations at the Indian Institute of Technology, Mumbai, India. Consistent with much of the ARC (financial support) model, while an ARC faculty (Prof. Vazirani) funds one of the postdocs using NSF funding, the other one is supported by matching funds from ARC.

New inductees as ARC faculty include Lance Fortnow (Chair of CS), Sebastian Pokutta (ISYE) and Grigory Blekherman (Math).

Recent Prizes and Achievements:

Nina Balcan, Ton Dieker and Chris Peikert were awarded the **NSF CAREER** awards.

Grigory Blekherman was awarded the **Alfred P. Sloan Fellowship** in Mathematics in 2012.

Dieker received **The Erlang Prize** from the Applied Probability Society of INFORMS for “outstanding contributions to several areas, including the theory of stochastic processes, stochastic networks, and stochastic analysis of algorithms.

ARC Faculty Bill Cook, Dana Randall, Prasad Tetali and Robin Thomas have been recognized as **American Math Society Fellows** in 2012.

Ruta Mehta’s Ph.D. thesis titled “Nash Equilibrium Computation in Various Games” received the **ACM India Dissertation** Award, 2012. Thesis submitted in academic years 2010-2011 and 2011-2012 were considered for the competition.

Lance Fortnow published a book -- **The Golden Ticket: P, NP and the search for the impossible**. Princeton University Press, Princeton, 2013. It was chosen as the "Nota Bene" book of the week in the Chronicle of Higher Education Review.

ARC Director’s Note:

In summary, during 2012 ARC faculty organized several high quality research workshops, hosted high profile scientists who have collaborated with Georgia Tech faculty, students and postdocs. ARC continued to catalyze and foster cross campus collaborations, keeping its commitment to playing an Algorithms ThinkTank role. ARC has kept the focus on research at all levels (undergraduate included), while contributing to the educational mission of Georgia Tech by hosting tutorials and expository lectures by experts and established scientists.

ACKNOWLEDGMENTS

Expert Admin Support

ARC director and ARC faculty gratefully acknowledges the very valuable support that **Ms. Elizabeth Ndongi** continues to provide on many ARC matters. Without her able support the management of the center and various logistics would be that much harder.

ARC director and Theory faculty are also thankful to the generous help and support **Ms. Dani Denton** provides, particularly during the hosting of workshops and special events.

This camera-shy person has no business to help ARC, but has been invaluable to the ARC director on many matters, including website maintenance, workshop registration and coordination with ACO events. **Ms. Annette Rohrs** in the School of Mathematics is undoubtedly an inspiration to every Georgia Tech employee. Thank you, Annette!