Ankit Sharma

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Research Interests

Algorithmic Game Theory, Approximation Algorithms, Learning Theory

Educational Qualifications

- **Graduate Student, Computer Science Department, Carnegie Mellon University**
  Advisors: Prof. Anupam Gupta and Prof. Avrim Blum
  September 2009 – present
- **Bachelor of Technology, Computer Science and Engineering** CPI: 9.9/10
  Indian Institute of Technology Kanpur, India
  Graduated in May 2008

Publications

- **Welfare and Profit maximization with Production costs**
  Avrim Blum, Anupam Gupta, Yishay Mansour, Ankit Sharma
  In Proceedings of Foundations of Computer Science (FOCS), 2011
- **Asymmetric Spite in Auctions**
  Ankit Sharma, Tuomas Sandholm
  In Proceedings of AAAI Conference on Artificial Intelligence, 2010
- **Using Personal Electronic Device for Authentication-Based Service Access**
  Abhishek Gaurav, Ankit Sharma, Vikas Gelara, Rajat Moona
  In Proceedings of IEEE International Conference on Communication, 2008
- **Implementation of a Cooperative MAC protocol using a Software Defined Radio Platform**
  Ankit Sharma, Vikas Gelara, Shashi Raj Singh, Thanasis Korakis, Pei Liu, Shivendra Panwar
  In Proceedings of IEEE Workshop on Local Area Network and Metropolitan Area Networks, 2008
- **Conformal Nonlinear Fluid Dynamics from Gravity in Arbitrary Dimensions**
  Sayanthani Bhattacharyya, R. Loganayagam, Ipsita Mandal, Shiraz Minwalla, Ankit Sharma
  Journal of High Energy Physics, December 2008

Current Research

- **The complexity of submodular functions**
  Nikhil Devanur, Roy Schwartz, Ankit Sharma, Mohit Singh
- **Stochastic matching for kidney exchange**
  Avrim Blum, Anupam Gupta, Ariel Procaccia, Ankit Sharma
- **When Information helps, differentially privately**
  Avrim Blum, Jamie Morgenstern, Adam Smith, Ankit Sharma
- **A mechanism without money for public project selection**
  Avrim Blum, Anupam Gupta, Ariel Procaccia, Ankit Sharma

Patents

1. **Using mobile device for authentication and service-access**
   Ankit Sharma, Abhishek Gaurav, Vikas Gelara, Rajat Moona
   Patent application number: 1018/Del/2008 dated April 21, 2008

Research Experience

1. **Graduate Student** September 2009 – present
   Advisors: Prof. Anupam Gupta and Avrim Blum
   Department of Computer Science, Carnegie Mellon University, Pittsburgh

2. **Microsoft Research Intern** May – August 2012
   Mentors: Mohit Singh and Nikhil Devanur
   Microsoft Research, Redmond

3. **Project Associate** September 2008 – April 2009
   Advisor: Prof. Surender Baswana
   Department of Computer Science, Indian Institute of Technology Kanpur, India

4. **Visiting Students' Research Program (VSRP)** May – July 2008
   Advisor: Prof. Shiraz Minwalla
   Department of Theoretical Physics, Tata Institute of Fundamental Research, India

Awards and Honors

1. Secured **All India Rank 4** in Indian Institute of Technology, Joint Entrance Examination (IITJEE), 2004.
2. Recipient of Indian Institute of Technology Kanpur "**Certificate of Merit Award for Academic Excellence**" in Undergraduate Programme for the years 2004-2005 and 2005-2006.
3. Selected for '**Summer Undergraduate Research Grant for Excellence**' (SURGE) Programme-2006, IIT Kanpur and '**Visiting Students' Research Program**' (VSRP) - 2008 at Tata Institute of Fundamental Research (TIFR), Mumbai, India.
4. Selected up to **National Level in Indian Chemistry Olympiad** and qualified the first and second levels of **National Talent Search Examination** (NTSE), India.

Research Reports

- **An O(log(n)) fully-dynamic algorithm for maximum-matching in a tree**
  Ankit Sharma, Manoj Gupta, Surender Baswana
  arXiv:0901.2900, (2009)
- **Analyzing Branch Predictions**
  Ankit Sharma, Sabyasachi Ghosh
  Undergraduate Thesis under the guidance of Prof. Mainak Chaudhari
- **Bilinear complexity of checking matrix multiplication**
  Ankit Sharma, Sagarmoy Dutta
  Course project under the guidance of Prof. Piyush Kurur

Graduate Courses

i) Foundations of Electronic Marketplaces
ii) Computational Complexity
iii) Advanced Algorithms
iv) Learning Theory
v) Coding Theory
vi) Randomized Algorithms
vii) Analysis of Boolean Functions*
viii) Linear and Semidefinite Programming*

(*) Audited

Names and contacts for Letters of Reference

i) Avrim Blum (avrim@cs.cmu.edu)
ii) Anupam Gupta (anupamg@cs.cmu.edu)
iii) Ariel Procaccia (arielpro@cs.cmu.edu)
iv) Mohit Singh (mohits@microsoft.com)

A brief description of the major research projects begins on the following page.

Major Research Projects

1. **The complexity of submodular functions**
   with Nikhil Devanur, Roy Schwartz and Mohit Singh
   Problem Statement: In this project, we explore the complexity of the class of submodular functions vis-à-vis some natural sub-classes of submodular functions. Specifically, do sub-classes of submodular functions such as matroid rank sum functions and directed cut functions capture *most* of the complexity of submodular functions? In particular, can these sub-classes approximate well any general submodular function?

   Contribution: *Ongoing work.*

2. **Stochastic Matching for Kidney exchange**
   with Avrim Blum, Anupam Gupta, Ariel Procaccia
   Problem Statement: We are given a graph $G(V, E)$, and we draw a random graph $G'(V, E')$, where every edge $e \in E$ is present in E' independently with some known probability p_e. How do we choose a subgraph H of G, subject to certain restrictions, such that over the draws of G', the corresponding graph H' has maximum expected size of maximum matching?

   This problem models the Kidney exchange market where every node in the graph G corresponds to a patient-donor pair, and an edge e between two nodes a and b implies that kidney of donor of node a can be received by the patient of node b and vice-versa. Without conducting medical tests on a particular donor and patient, we cannot determine whether the kidney of the donor is compatible with the body of the patient. However, without the test and using some medical information of the donor and the patient, we can determine the probability with which the compatibility shall hold, and these are denoted by p_e. Since tests are expensive to conduct, we would like to choose a subset of tests to conduct (determined by the subgraph H) such that, in expectation over the outcome of the tests, these tests should suffice to match the donors to patients.

   Contribution: *Ongoing work.*

3. **When Information helps, differentially privately**
   with Avrim Blum, Jamie Morgenstern, Adam Smith
   Problem Statement: Are there games that can enter into equilibria with low social welfare, but providing some public information to the players can avoid such equilibria? And can this information be thin enough to not reveal too much about the types of the players and yet be helpful in avoiding the bad equilibria?

   We consider some natural classes of games such as congestion games where some equilibria can have a very low social welfare. However, if a central entity can collect the types of various players and then publish some public information, then that can potentially help the players to play strategically and yet avert the game from making low social welfare. How we can incentivize the players to report their types truthfully to this central entity and how this entity can publish the information that is helpful and yet differentially private for each player's private type, is the topic of study for this project.

   Contribution: *Ongoing work.*

4. **Mechanism Design without money**
   with Avrim Blum, Anupam Gupta and Ariel Procaccia
   Problem Statement: Imagine that a mayor of a city has to choose five out of a possible ten public projects to fund. She decides to base her decision on the preference of the people and asks everyone to report their preference. Each person is self-interested and different sections of society have conflicting interests. While the student community prefers a better public transport, the business community would like to have a better industrial infrastructure. A naive mechanism to combine the reported preferences to compute the decision might be easily manipulable through strategic reporting of preferences. Furthermore, the scenario does not allow use of money to incentivize agents to report truthfully.

   To model the situation, we restate the problem in the following terms. We would like to pick k sets out of a possible of n sets to maximize coverage. The elements in the universe are self-interested agents and their membership information is private to them. We would like to design an incentive compatible mechanism without money that optimizes max k-coverage.

   Contribution: *Ongoing work.*

5. **Welfare and Revenue maximization with Production Costs**
   with Avrim Blum, Anupam Gupta and Yishay Mansour
   Problem Statement: Consider a market scenario with a single seller, having a bunch of items to sell, and buyers coming to the seller in an online fashion. The seller is allowed to price individual items and a buyer buys the set which maximizes her utility. The goal is to come up with a pricing schemes that maximize social welfare and the revenue of the seller.

Prior literature has considered situations where the buyer has either a limited or an unlimited copies of each item. In the current research work, however, we initiate the study of a more realistic scenario where every item has an increasing marginal production cost curve. Hence, instead of a limited supply, the seller can procure an additional copy of an item, albeit by paying an increasing marginal cost. Further, we allow buyers to have arbitrary combinatorial preferences.

Contribution:

- Developed pricing schemes that achieve a constant approximation to optimal social welfare for polynomial and logarithmic production curves and a logarithmic approximation for a general increasing production curve.
- Developed a profit maximization pricing schemes that achieves a logarithmic approximation to the optimal profit for a general increasing production curve.

6. **Spiteful Bidding in Auctions**
with Tuomas Sandholm
Problem Statement: The CEO of a major oil company might be losing the auction of an oil-field. Yet she continues to participate in the auction because she wants to minimize the negative utility on losing by making her competitor, who would win the auction, pay a high price for the win. This negative dependence of utility on others' surplus is referred to as 'spite' in auctions. Prior research work considered each bidder to be equally 'spiteful'; this works breaks this assumption of symmetry which need not hold in real-world situations.
Contribution:

   - Found equilibrium bidding functions for the four auction mechanisms – first-price and second-price sealed-bid, Dutch and English auctions.
   - Examined the effect of 'spite' on winner determination and the revenue; bidders with lower valuations can be winners and there is no absolute revenue ranking among the various auction mechanisms.

7. **Dynamic Algorithm for Maximum Matching**
with Surender Baswana and Manoj Gupta, Indian Institute of Technology Kanpur, India
Problem Statement: Dynamic Algorithms aim to maintain properties of graphs under insertion and deletion of edges without the need to compute from scratch each time the graph is updated. The research project aimed to develop a dynamic algorithm for maximum-matching in a graph.
Contribution:

   - Developed a fully-dynamic algorithm for maintaining cardinality of maximum-matching in a tree in $O(log(n))$ time.

8. **Bilinear complexity of checking matrix multiplication**
with Piyush P. Kurur, Indian Institute of Technology Kanpur, India
Problem Statement: In this research project, we attempted to construct a complexity measure of randomized testing of a bilinear map. Towards this aim, notion of 'checking-rank' was defined. This research attempted to prove the optimality of Frievalds test using the constructed complexity measure.
Contribution:

   - Two conjectures were made which together prove the optimality of Frievalds test under the constructed complexity measure.

9. **Conformal Nonlinear Fluid Dynamics from Gravity in Arbitrary Dimensions**
with Shiraz Minwalla, Department of Theoretical Physics, Tata Institute of Fundamental Research, India
Problem Statement: AdS/CFT correspondence conjectures about the correspondence between certain solutions of gravity and certain solutions of gauge theory. This research project involved finding AdS_d metric corresponding to a conformal fluid, with an underlying strongly-coupled field theory, in a d-1 dimensional space time using AdS/CFT correspondence.
Contribution:

   - Calculated parts of the AdS metric correct up to second order in derivative of velocity and temperature of the conformal fluid and calculated the stress tensor of the conformal fluid up to first order.