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Vittorio Bilò · Michele Flammini (Eds.)

Algorithmic Game Theory

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Editors
Vittorio Bilò
University of Salento
Lecce
Italy

Michele Flammini
University of L'Aquila
L'Aquila
Italy

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Preface

This volume contains the papers presented at the 10th International Symposium on Algorithmic Game Theory (SAGT 2017), which was held on September 12–14, 2017, in L'Aquila, Italy.

This year, we received a record number of 66 submissions. Each submission was reviewed by at least three Program Committee members. After a careful reviewing process, the committee decided to accept 30 papers. The program also included three invited talks by distinguished researchers in Algorithmic Game Theory: Michal Feldman (Tel-Aviv University), Martin Hoefer (Goethe University), and Nicole Immorlica (Microsoft Research).

To accommodate the publishing traditions of different fields, the authors of accepted papers could request that only a one-page abstract of the paper appears in the proceedings. Among the 30 accepted papers, the authors of 4 papers opted to publish a one-page abstract. The accepted submissions cover various important aspects of algorithmic game theory, such as auctions, computational aspects of games, congestion games, network and opinion formation, mechanism design, incentives and regret minimization, and resource allocation. The best paper award, generously supported by Springer, has been shared between the papers *Tight Welfare Guarantees for Pure Nash Equilibria of the Uniform Price Auction* by Georgios Birmpas, Evangelos Markakis, Orestis Telelis and Artem Tsikiridis, and *Online Random Sampling for Budgeted Settings* by Alon Eden, Michal Feldman and Adi Vardi.

We would like to thank all authors who submitted their research work, the Program Committee members, and the external reviewers who assisted them, for their wonderful work. We are indebted to the Gran Sasso Science Institute of L'Aquila, Fondazione Cassa di Risparmio della Provincia dell'Aquila, the Department of Mathematics and Physics "Ennio De Giorgi" of the University of Salento, EATCS, and Springer for their generous support. We thank Anna Kramer and Alfred Hoffmann at Springer for helping with the proceedings. We are grateful for the use of the EasyChair paper management system.

July 2017

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Abstracts

Position Ranking and Auctions for Online Marketplaces

Leon Yang Chu, Hamid Nazerzadeh, and Heng Zhang

Data Sciences and Operations Department, University of Southern California, Los Angeles, CA, USA, 90089
{leonyzhu,hamidnz,Heng.Zhang.2019}@marshall.usc.edu

Abstract. E-commerce platforms such as Amazon, Ebay, Taobao, and Google Shopping connect thousands of sellers and consumers everyday. When a consumer enters a search keyword related to a product of interest, the platform's search engine returns a list. Typically, the consumer looks for a desired item by searching downward in the list. With a large volume of returned results, consumers rarely consider all of the items because examining each option is costly. Therefore, the ranking of items is an important decision that determines the welfare of sellers, consumers and the platform. In this work, we study how such platforms should rank products displayed, and utilize the top and most salient slots. Building on the optimal sequential search theory, we present a model that considers consumers' search costs and the externalities sellers impose on each other. This model allows us to study a multi-objective optimization, whose objective includes consumer and seller surplus, as well as the sales revenue, and derive the optimal ranking decision. One of the challenges in obtaining a satisfactory solution in practice is information asymmetry. The platform may be unaware of sellers' private benefits of each consumer purchase, for example, profits, brand effects, and so on. We show that an uninformed decision, one in which sellers' private valuations are unknown to the platform, can lead to an arbitrary loss of average welfare. We propose selling the platform's top slots to extract private information, using the *surplus-ordered ranking* (SOR) mechanism. This mechanism is motivated in part by Amazon's sponsored search program. We study this mechanism in a mechanism design framework, and show that it is a near-optimal solution. In addition, when the platform sells all slots, we show that our mechanism can be implemented as a Nash equilibrium in a modified generalized second price (GSP) auction.

Full paper available online at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2926176.

Asymptotic Existence of Fair Divisions for Groups

Pasin Manurangsi[1] and Warut Suksompong[2]

[1] Department of Computer Science, UC Berkeley
253 Cory Hall, Berkeley, CA 94720, USA
pasin@berkeley.edu
[2] Department of Computer Science, Stanford University, 353 Serra Mall,
Stanford, CA 94305, USA
warut@cs.stanford.edu

The problem of dividing resources fairly occurs in many practical situations and is therefore an important topic of study in economics. In this paper, we investigate envy-free divisions in the setting where there are multiple players in each party. While all players in a party share the same set of resources, each player has her own preferences. In this generalized setting, we consider a division to be envy-free if every player values the set of items assigned to her group at least as much as that assigned to any other group.

We show that under additive valuations drawn randomly from probability distributions, when all groups contain an equal number of players, an envy-free division is likely to exist if the number of goods exceeds the total number of players by a logarithmic factor, no matter whether the players are distributed into several groups of small size or few groups of large size. In particular, any allocation that maximizes social welfare is likely to be envy-free. A similar result holds when there are two groups with possibly unequal numbers of players and the distribution on the valuation of each item is symmetric.

To complement our existence results, we show on the other hand that we cannot get away with a much lower number of items and still have an envy-free division with high probability. In particular, if the number of items is less than the total number of players by a superconstant factor, or if the number of items is less than the total number of players and the number of groups is large, the probability that an envy-free division exists is low. This leaves the gap between asymptotic existence and non-existence of envy-free divisions at a mere logarithmic factor.

Finally, we tackle the issue of truthfulness and show that a simple truthful mechanism, namely the random assignment mechanism, is α-*approximate envy-free* with high probability for any constant $\alpha \in [0,1)$. Approximate envy-freeness means that even though a player may envy another player in the resulting division, the values of the

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The full version of this paper is available at http://arxiv.org/abs/1706.08219.

player for her own allocation and for the other player's allocation differ by no more than a multiplicative factor of α. Our result shows that it is possible to achieve truthfulness and approximate envy-freeness simultaneously in a wide range of random instances, and improves upon the previous result for the setting with one player per group in several ways.

Approximate Maximin Shares for Groups of Agents

Warut Suksompong

Department of Computer Science, Stanford University, 353 Serra Mall, Stanford, CA 94305, USA
warut@cs.stanford.edu

We consider the problem of fairly allocating indivisible goods to interested agents. Several notions of fairness have been proposed, including envy-freeness and proportionality. However, the existence of allocations satisfying these notions, or even a multiplicative approximation of them, cannot be guaranteed. A notion that was designed to fix this problem and has been a subject of much interest in the last few years is the maximin share.

In this paper, we apply the concept of maximin share to a more general setting of fair division in which goods are allocated not to individual agents, but rather to groups of agents who can have varying preferences on the goods. Several practical situations involving fair division fit into this model. For instance, an outcome of a negotiation between countries may have to be approved by members of the cabinets of each country who have different opinions on the outcome. Another example is a large company or university that needs to divide its resources among competing groups of agents (e.g., departments in a university). The agents in each group have different and possibly misaligned interests; the professors who perform theoretical research may prefer more whiteboards and open space in the department building, while those who engage in experimental work are more likely to prefer laboratories.

We extend the maximin share to groups in a natural way by calculating the maximin share for each agent using the number of groups instead of the number of agents. When there are two groups, we completely characterize the cardinality of agents in the groups for which it is possible to approximate the maximin share within a constant factor regardless of the number of goods. In particular, an approximation is possible when one of the groups contain a single agent, when both groups contain two agents, or when the groups contain three and two agents respectively. In all other cases, no approximation is possible in a strong sense: There exists an instance with only four goods in which some agent with positive maximin share necessarily gets zero utility.

We then generalize to the setting with several groups of agents. On the positive side, we show that a constant factor approximation is possible if only one group contains more than a single agent. On the other hand, we show on the negative side that when all groups contain at least two agents and one group contains at least five agents, it is possible that some agent with positive maximin share will be forced to get zero utility, which means that there is no hope of obtaining an approximation in this case.

The full version of this paper is available at http://arxiv.org/abs/1706.09869.

On Black-Box Transformations in Downward-Closed Environments

Warut Suksompong

Department of Computer Science, Stanford University, 353 Serra Mall, Stanford, CA 94305, USA
warut@cs.stanford.edu

A major line of work in algorithmic mechanism design involves taking a setting where the optimization problem is computationally intractable, and designing computationally tractable mechanisms that yield a good global outcome and such that the agents have a truth-telling incentive. The widespread success of designing such mechanisms has raised the question of whether there exists a "black-box transformation" for transforming any computationally tractable algorithm into a computationally tractable mechanism without degrading the approximation guarantee. Chawla et al. showed that no fully general black-box transformation exists for single-parameter environments.

Despite this negative result, it is still conceivable that there are transformations that work for certain large subclasses of single-parameter environments. One important subclass is that of downward-closed environments, which occur in a wide variety of settings in mechanism design. In this paper, we consider such settings and assume, crucially, that the black-box transformation is aware that the feasible set is downward-closed. We investigate the potentials and limits of black-box transformations when they are endowed with this extra power.

We begin by showing the limits of black-box transformations in downward-closed environments. We prove that such transformations cannot preserve the full welfare at every input, even when the private valuations can take on only two arbitrary values. Preserving a constant fraction of the welfare pointwise is impossible if the ratio between the two values $l < h$ is sublinear, i.e., $h/l \in O(n^{\alpha})$ for $\alpha \in [0,1)$, where n is the number of agents, while preserving the approximation ratio is also impossible if the values are within a constant factor of each other and the transformation is restricted to querying inputs of Hamming distance $o(n)$ away from its input.

Next, we show the powers of black-box transformations in downward-closed environments. We prove that when the private valuations can take on only a constant number of values, each pair of values separated by a ratio of $\Omega(n)$, it becomes possible for a transformation to preserve a constant fraction of the welfare pointwise, and therefore of the approximation ratio as well. The same is also true if the private valuations are all within a constant factor of each other. Combined with the negative results, this gives us a complete picture of constant-fraction welfare-preserving transformations for multiple input values. Not only are these results interesting in their own right, but they also demonstrate the borders of the negative results that we can hope to prove.

The full version of this paper is available at http://arxiv.org/abs/1707.00230.

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