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Preface

Game Theory Meets Theoretical Computer Science

Bearing the title "Game Theory Meets Theoretical Computer Science", this is probably the first special issue devoted to the intersection of Game Theory and Theoretical Computer Science, an area of study that currently witnesses a lot of flourishing interest and attention. A truly extraordinary amount of research activity is now being observed at the intersection of these two fields.

One may ask why, really, it is so interesting to consider this intersection? There are a plethora of reasons, and this has led to a plethora of subareas in this already large intersection. We shall only touch on some of them that we feel are the most prominent.

- First, the algorithmic foundations of Game Theory are not yet developed. Game Theory has answered many questions of existence in a satisfactory way (in many occasions); however, algorithmic questions of actually finding game-theoretic objects with prescribed mathematical properties (for example, the best *Nash equilibrium*) have only recently started to undergo a systematic complexity-theoretic investigation. It is hoped that Algorithmic Game Theory will experience the same rapid development as Algorithmic Graph Theory or Algorithmic Geometry, to name two leading examples.
- Second, there are many phenomena in Computer Science that involve the interaction of antagonistic entities with conflicting interests. Modeling these selfish entities using the concepts of Game Theory is natural and appropriate, and invites Theoretical Computer Science to take up the story and analyze the resulting models of selfish computation from its own point of view.
- Third, it has been discovered that classical Game Theory can offer some strong proof techniques for central problems in Computational Complexity Theory—most notably in Descriptive Complexity and Model Checking. It is hoped that insisting on adopting such strong proof techniques from Game Theory will lead to further advances in these areas.
- Fourth, game semantics and game models have found many applications in Program Semantics and Logics of Programs. In many cases, appropriate games have revealed links between syntax and semantics, and they have led to the development of fully abstract models for a variety of programming languages. This work on semantics is leading in turn to algorithmic methods which provide a basis for a compositional approach to software model-checking and program analysis. It is expected that such fruitful applications will continue to emerge.

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These subareas at the intersection of Game Theory and Theoretical Computer Science were used to define topics of particular interest for the special issue, and those were advertised in the Call for Papers. In response to the Call for Papers, 16 submissions were received. Shortly thereafter, one of the submissions was withdrawn. All the remaining ones were refereed according to the usual procedures of TCS; the final decisions conformed to the high standards of the journal. As a result, this Special Issue includes 11 high-calibre research articles, representing a wide range of topics at the heart of the intersection between Game Theory and Theoretical Computer Science.

1. The paper “A Mathematical Model for the TCP Tragedy of the Commons”, by L.L. Fernández et al., introduces a novel game-theoretic framework for the modeling and analysis of TCP/IP networks with selfish hosts. The hosts want to monopolize the shared resources of the network. The paper provides a very thorough analysis of the situation, and the analysis is validated with a set of simulations.
2. The paper “On the Approximability of the Range Assignment Problem on Radio Networks in Presence of Selfish Agents”, by C. Ambühl et al., provides an interesting selfish formulation of the range assignment problem in ad hoc wireless networks. The paper investigates the existence of *truthful* payment schemes—ones that induce the stations in a network to faithfully follow the instructions of the network manager. The paper presents both positive and negative results.
3. The paper “Games on Triangulations”, by O. Aichholzer et al., analyzes several interesting combinatorial games played on planar triangulations. The paper treats three classes of such games. For several instances from the three classes, polynomial-time algorithms are provided to find winning strategies. Connections to other known combinatorial games are also pointed out.
4. The paper “PSPACE-Completeness of Sliding Block Puzzles and Other Problems through the Nondeterministic Constraint Logic Model of Computation”, by R. Hearn and E. Demaine, studies a new combinatorial game on weighted directed graphs. The algorithmic problem is whether a particular edge can be reversed by a reversing procedure that respects some minimum in-flow constraints on vertices. By identifying interesting connections to Constraint Logic, several versions of the problem are shown PSPACE-hard or PSPACE-complete.
5. The paper “Non-Cooperative Computation: Boolean Functions with Correctness and Exclusivity”, by Y. Shoham and M. Tennenholtz, introduces the novel concept of *non-cooperative computation*; this refers to the joint computation of a function by a collection of (not necessarily truthful) selfish agents. The main result is a very interesting characterization of the Boolean functions that remain computable in this setting of non-cooperative computation.
6. The paper “Computation in a Distributed Information Market”, by J. Feigenbaum et al., provides an interesting game-theoretic model for an information market. The model is distributed; the authors study the convergence to equilibrium in their model. The paper presents interesting lower and upper bounds on the convergence to the equilibrium prices, for a variety of financial situations.
7. The paper “The Structure and Complexity of Extreme Nash Equilibria”, by M. Gairing et al., studies the combinatorial and algorithmic properties of extreme (best or worst) Nash equilibria for a game that models selfish routing over a very simple,

non-cooperative network. The paper suggests that the *worst-case* Nash equilibrium is the *fully mixed Nash equilibrium*, where all probabilities of the users are strictly positive. This is posed as a (yet unproven) conjecture.

8. The paper "The First Order Definability of Graphs with Separators via the Ehrenfeucht Game", by O. Verbitsky, uses Ehrenfeucht games to prove a first-order formula characterization for trees of bounded degree and for Hamiltonian outerplanar graphs. The proof techniques exploit an interesting relation between quantifier rank and the length of the Ehrenfeucht game.
9. The paper "Syntax vs. Semantics: A Polarized Approach", by O. Laurent, studies a notion of sliced proof nets for the polarized fragment of Linear Logic, and a corresponding game semantics. A very tight correspondence in the form of an equivalence of categories is established between the syntax and this game model, continuing a line of development in game semantics of characterizing the space of proofs of logical systems with Full and Faithful Completeness theorems.
10. The paper "Games for Complexity of Second-Order Call-by-Name Programs", by A.S. Murawski, shows that the problem of deciding observation equivalence between programs in a simple imperative language with block structure and procedure calls is PSPACE-complete. This result is obtained based on an analysis of a game-semantical model of this language, showing the power of the game semantics approach, which has yielded the first fully-abstract models for such languages.
11. The paper "Sequential Algorithms and Strongly Stable Functions", by P.-A. Melliès, concerns the relationship between extensional and intensional aspects of the semantics of higher-order functional programs. It develops a graph representation of the games corresponding to the sequential algorithms model of Berry and Curien, and uses this to give a game-theoretic proof of a result originally due to Ehrhard, that the extensional collapse of the sequential algorithms hierarchy coincises with the hierarchy of strongly stable functions.

We sincerely hope that the collection of articles in this volume will attract further interest in these topics, and stimulate even more exciting research at this fascinating meeting-point of Game Theory and Theoretical Computer Science.

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