Report from Dagstuhl Seminar 17111

Game Theory in AI, Logic, and Algorithms

Edited by

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Abstract

This report documents the program and the outcomes of Dagstuhl Seminar 17111 "Game Theory in AI, Logic, and Algorithms".

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1 Executive Summary

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The Dagstuhl Seminar *17111: Game Theory in AI, Logic, and Algorithms* was held from March 12–17, 2017. The seminar explored research challenges at the interface of computing and game theory. This area has seen fervent research activity in recent times. Specifically, game theoretic ideas have found currency in three key areas of computer science: in the *algorithms* community, algorithmic game theory is now a well-established sub-field; in *formal methods*, model checking and synthesis problems have been studied using game-theoretic concepts; and in *artificial intelligence*, game theory has come to provide the fundamental conceptual vocabulary for the field of multi-agent systems. Despite this manifest common interest, there is surprisingly little trade between game-theoretic approaches in these different subfields of computer science. Our aim in this seminar was to start to build some bridges between these three areas.

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3 Program

The seminar's program consisted of an array of talks by speakers from algorithms, formal methods, and artificial intelligence, as well as discussion on how the topics discussed in the various talks connected with each other. Now we summarize this program.

3.1 Monday, March 13

The program for the first day consisted of three tutorials, one from each of the three communities represented at the seminar. The goal of these tutorials was to introduce to the participants the view of game theory from the perspectives of these communities, and to set the stage for subsequent interdisciplinary discussions.

Of the tutorial speakers, Moshe Vardi surveyed the long history of game-theoretic ideas in logic and formal methods, in particular highlighting the deep relationship between game theory and the system synthesis problem. Mihalis Yannakakis surveyed recent developments in algorithmic game theory. Michael Wooldridge spoke about the role of game theory in artificial intelligence, specifically multi-agent systems.

3.2 Tuesday, March 14

The second day started with a session on game-theoretic results of interest in both formal methods and algorithms. In this session, Rasmus Ibsen-Jensen summarized a recent quasi-polynomial algorithm for parity games. After this, Orna Kupferman and Tami Tamir gave a talk on enriching classical definitions of games using techniques from formal methods.

The next session covered games from economics. Evdokia Nikolova spoke of risk-averse selfish routing, while Maria Polukarov discussed trembling hand equilibria of voting games.

The session that followed was on security games. Arunesh Sinha discussed the Stackelberg game approach to safe and secure systems, and Yuan Deng spoke about disarmament games. Antonin Kucera presented a method for efficient strategy synthesis for large and fully connected patrolling graphs.

The next session consisted of two broad talks on privacy. Sampath Kannan gave a broad introduction to algorithmic mechanisms for privacy. Justin Hsu talked about formal methods for privacy.

The day ended with an open problems session. Here, Rayna Dimitrova presented an open problem on robot routing, and Jan Kretinsky presented an open question on winning strategies that are obtained by learning with guarantees. Jean-Francois Raskin spoke about some open questions about how to mix reasoning about certainty and expectation.

3.3 Wednesday, March 15

Wednesday's program was half a day long, given that an excursion was scheduled in the afternoon. The first session of the day focused on the relationship between system synthesis and games. Here, Kim Larsen talked about controller synthesis for cyber-physical systems, and Igor Walukiewicz gave a talk on the challenge of synthesizing distributed systems. Ruediger Ehlers ended the session with a talk on the environment model in synthesis.

In an open problems session that followed, Valentin Goranko presented some challenges in games of pure coordination without communication. Evdokia Nikolova spoke about some open questions about dynamic congestion games in algorithmic game theory, specifically highlighting how models of system dynamics in formal methods may be of interest in algorithms.

3.4 Thursday, March 16

The morning session of this day consisted of two talks on game theory in algorithms. Nicole Immorlica spoke about Yiling Chen gave a talk on informational substitutes and compliments. In addition, Patricia Bouyer talked about average energy games.

In the afternoon, we had a session on learning. Sanjit Seshia gave a talk on modeling human reward functions in autonomous driving, and Eric Balkanski gave a talk on statistical cost sharing, specifically learning fair cost allocations from samples. Thomas Brazdil gave a talk on decision trees.

The final session of the day was on equilibria. Veronique Bruyere talked about subgame perfection, and Kousha Etessami spoke about trembling-hand perfect equilibria, and quasi-perfect equilibria, in n-player extensive form games of perfect recall. The day ended with a talk by Suguman Bansal on computing equilibria in a new class of games called regular repeated games.

3.5 Friday, March 17

The last day of the seminar primarily involved discussions about the role of game theory in the three areas discussed in the seminar.

4 Conclusions

Perhaps the biggest achievement of the seminar was to educate participating resesarchers about the role of game theory in computer science research outside of their immediate subareas. The roles of game theory in the three focus areas of the seminar – algorithms, formal methods, and artificial intelligence – are rather different. Algorithmic game theory tends to focus on algorithmic computation in games (in particular computing solution concepts) and the use of game theoretic techniques in the analysis and construction of distributed computer systems (for example algorithmic mechanism design). In logic and formal methods, games are used in reasoning about branching behaviors of systems and verification of systems containing multiple components, as well as system synthesis. In artificial intelligence, game theoretic concepts are routinely used in the analysis of multi-agent systems. Most researchers working in one of the three areas do not have opportunities to experience the roles of game theory outside of their areas on a day-to-day basis. By offering alternative perspectives on games in computer science, the seminar will possibly influence their future research agendas.

For example, a participant who worked on algorithmic game theory was fascinated by the way formal methods research models dynamics of games, in contrast to much of algorithmic game theory research, which tends to study games that do not evolve over time. There were also discussions on the use of solution concepts such as trembling-hand equilibria, recently

investigated in algorithmic game theory, in formal methods, and the use of techniques from contemporary formal methods in analysis of multiagent systems.

At the same time, the seminar did not lead to a conclusive agenda, with concrete action items, that unifies the three strands of game-theoretic research. This is perhaps not surprising given that the research communities of formal methods, multiagent systems, and algorithms do not have much overlap, and building up any interdisciplinary research agenda takes time. However, we believe that the seminar created some important conversations between game theorists in the three communities that we targeted, and as such, was a moderate success.

Participants

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ENS – Cachan, FR
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Masaryk University – Brno, CZ
- Véronique Bruyère
University of Mons, BE
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Harvard University – Cambridge, US
- Yuan Deng
Duke University – Durham, US
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Universität des Saarlandes, DE
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Hebrew University – Jerusalem, IL
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