The State of Representing and Solving Games

By Tuomas Sandholm

Carnegie Mellon University, Pennsylvania

With High-Level Panel of Leaders in Science, Technology, On-the-Ground Action, and Policy

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For Remote Participation, please register HERE

ABSTRACT: Game-theoretic solution concepts provide meticulous definitions of how rational parties should act. That has enabled humans to think rigorously about strategic interactions, leading to game theory revolutionizing many fields such as economics, political science, and biology. So far, game theory has mainly been used for reasoning by humans. The models have therefore been quite stylized and coarse: small enough for humans to solve in their heads or by paper and pen. The goal has been to draw insights from such models, which humans then judiciously apply to the drastically more complicated real world. The boundaries of game theory have thus been defined by the limits of humans. However, many - arguably most - important game classes lie beyond those boundaries. There is now another, more nascent, use of game theory that goes beyond human intelligence. The game is computationally solved in its full detail - or else in a large, faithful abstraction thereof - as opposed to solving a small, stylized version to obtain insights for humans. Novel approaches, game representations, and algorithms from the last 18 years have enabled game theory to advance significantly beyond its traditional boundaries. I will discuss that state of the art. The talk is based on my presentation at the December 2021 Nobel Symposium: 100 Years of Game Theory, and also includes brand new results.

PRESENTER: Tuomas Sandholm is Angel Jordan University Professor of Computer Science at Carnegie Mellon University and a serial entrepreneur. His research focuses on the convergence of artificial intelligence, economics, and operations research. He is Co-Director of CMU AI. He is the Founder and Director of the Electronic Marketplaces Laboratory. He has published over 500 peer-reviewed papers, holds 25 patents, and his h-index is 91. In addition to his main appointment in the Computer Science Department, he holds appointments in the Machine Learning Department, Ph.D. Program in Algorithms, Combinatorics, and Optimization (ACO), and CMU/UPitt Joint Ph.D. Program in Computational Biology.

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Co-Chairs:

Laurette Dubé, PhD is the founding Chair and Scientific Director of the McGill Centre for the Convergence of Health Economics. She holds the James McGill Chair of Consumer and Lifestyle Psychology and Marketing. Her work has been published in top disciplinary journals in Psychology, Management and Medicine as well as in multidisciplinary journals. She holds an MBA in finance, and a PhD in behavioural decision making and consumer psychology. During her 2020-2021 sabbatical, she is a visiting scholar at the National Research Council of Canada and at the Pittsburgh Supercomputing Center, Carnegie Mellon, USA. https://thefutureeconomy.ca/interviews/ laurette-dube

Sergiu Sanielevici, Ph.D. is Director of Support for Scientific Applications at the Pittsburgh Supercomputing Center, a joint project of Carnegie Mellon University and the University of Pittsburgh. He has served as the Deputy Director of the Extended Collaborative Support Service of the US NSF XSEDE project and as the manager of its Novel and Innovative Projects program, fostering non-traditional and interdisciplinary applications of advanced computing and data resources since 2011. He is currently the Principal Investigator of the Bridges-2 project and co-Principal Investigator of the Neocortex project at PSC. Dr. Sanielevici is a proud alumnus of McGill University (Ph.D., Physics, 1986).

Panelists:

Joelle Pineau is the co-Managing Director of Meta AI, supporting labs across North America and Europe. She is also a faculty member at Mila and an Associate Professor and William Dawson Scholar at the School of Computer Science at McGill University, where she co-directs the Reasoning and Learning Lab. She holds a BASc in Engineering from the University of Waterloo, and an MSc and PhD in Robotics from Carnegie Mellon University. Dr. Pineau's research focuses on developing new models and algorithms for planning and learning in complex partially-observable domains. She also works on applying these algorithms to complex problems in robotics, health care, games and conversational agents. She serves on the editorial board of the Journal of Artificial Intelligence Research and the Journal of Machine Learning Research and is Past-President of the International Machine Learning Society. She is a recipient of NSERC's E.W.R. Steacie Memorial Fellowship (2018), a Fellow of the Association for the Advancement of Artificial Intelligence (AAAI), a Senior Fellow of the Canadian Institute for Advanced Research (CIFAR), a member of the College of New Scholars, Artists and Scientists by the Royal Society of Canada, and a 2019 recipient of the Governor General's Innovation Awards.

.Adrian Vetta is a Professor in Mathematics & Statistics and in Computer Science at McGill University. His field of study is algorithms and computation with a specific focus on decision-making processes, both human and automated. Dr. Vetta's research is interdisciplinary and has been published in a wide range of fields including computational biology, discrete mathematics, economics, genetics, machine learning, management and operations research, mathematical programming and optimization, telecommunications, and theoretical computer science. His current research focuses on fair and efficacious mechanism design with application to kidney exchanges, spectrum auctions, and cap-and-trade mechanisms.

Mark Winands is the chair of the Department of Advanced Computing Sciences at Maastricht University. He is a professor in machine reasoning, especially focussing on heuristic and adaptive search. He has published in international journals such as *Artificial Intelligence Journal, IEEE Transactions on Computational Intelligence and AI in Games*, *Journal of AI Research*, *Knowledge Based Systems*, *Information Sciences* and *Theoretical Computer Science*. He is widely known of investigating underlying principles of Monte-Carlo Tree Search (MCTS) for which he has received two NWO grants. He is frequently invited to speak on this topic at international meetings. Regarding other intelligent search techniques, he has made contributions in the minimax framework, hierarchical task networks and proof-number search.

Jörgen Weibull is professor at the Stockholm School of Economics. He is also affiliated with the KTH Royal Institute of Technology, Stockholm, and with the Institute for Advanced Study in Toulouse. His main field of research is non-cooperative and evolutionary game theory, with applications to economics, political science, and evolutionary biology. He is a member of the Royal Swedish Academy of Sciences and Fellow of Econometric Society.

Amy Greenwald is Professor of Computer Science at Brown University in Providence, Rhode Island. Greenwald was also a visiting researcher at the Artificial Intelligence Research Center at the Japanese National Institute of Advanced Industrial Science and Technology in Tokyo in 2018-19; a visiting researcher in the Algorithmic Economics Lab at Microsoft Research in New York City in 2015; and a visiting professor at the Erasmus Research Institute of Management in Rotterdam in 2011. She was named a Fulbright Scholar in 2011 (though she declined the award); she was awarded a Sloan Fellowship in 2006; she was nominated for the 2002 Presidential Early Career Award for Scientists and Engineers; and she was named one of the Computing Research Association's Digital Government Fellows in 2001. Before Brown, she worked for a short time as a post-doc at IBM's T.J. Watson Research Center, where her "Shopbots and Pricebots" paper was named Best Paper at IBM Research in 2000. Finally, Greenwald is active in promoting diversity in Computer Science, leading multiple K-12 initiatives in which Brown undergraduates teach computer science to Providence public school students.

Marc Lanctot has a strong background in multiagent learning, computational game theory, reinforcement learning, and game-tree search. He is a previous post-doctoral researcher at the Maastricht University Games and AI Group, under the supervision of Mark Winands. He received his PhD from the University of Alberta where he worked on sampling algorithms for equilibrium computation and decision-making in games, under the supervision of Michael Bowling. He completed his undergraduate and Master's degrees at McGill University's School of Computer Science and Games Research, under the supervision of Clark Verbrugge. He has given workshops and seminars, including a multiagent RL workshop at Laber Labs at NC State University, and has been interviewed about his research and interests.