Using Games to Understand Intelligence

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Over the last decades, games have become one of the most popular recreational activities, not only among children but also among adults. Consequently, they have also gained popularity as an avenue for studying cognition. Games offer several advantages, such as the possibility to gather big data sets, engage participants to play for a long time, and better resemblance of real world complexities. In this workshop, we will bring together leading researchers from across the cognitive sciences to explore how games can be used to study diverse aspects of intelligent behavior, explore their differences compared to classical lab experiments, and discuss the future of game-based cognitive science research.
Keywords: Games; Cognition; Big Data; Computation

Introduction

Machine learning researchers frequently focus on human-level performance in particular in games (Mnih et al., 2015). However, in these applications, human behavior is commonly reduced to a simple dot on a performance graph. Cognitive science, in particular theories of learning and decision making, could hold the key to unlock what is behind this dot, thereby gaining further insights into human cognition and the design principles of intelligent algorithms (Lake, Ullman, Tenenbaum, & Gershman, 2017). However, cognitive experiments commonly focus on relatively simple paradigms. We believe that the time is ripe for researchers from across the cognitive sciences to come together, discuss, and push forward paradigms that use games to research and understand human cognition (Opheusden et al., 2021; Opheusden & Ma, 2019). Our workshop will therefore consist of a diverse set of speakers to present on their current research on games, including word games (Hartshorne, Tenenbaum, & Pinker, 2018), physics games (Allen, Smith, & Tenenbaum, 2020), social games (Wu et al., 2020), and complex reinforcement learning environments (Kosoy et al., 2020; Şimşek, Algorta, & Kothiyal, 2016), as well as potential future application of games in their research.

While traditional in-lab experiments have been the main source of data to research cognition, the internet offers an opportunity to gather data sets that are several times bigger (Griffiths, 2014). Online games, played by thousands of players across the globe not only provide us with big data sets, they can additionally give us an insight into human behavior that has traditionally been hard to collect in the lab - for example hundreds of hours of interaction with a specific task (Stafford & Dewar, 2014).

Another interesting aspect of games is their ability to resemble the real world more closely. By using physical game engines, researchers can make precise, quantifiable comparisons between human and machine agents, for example in research of human tool use (Allen et al., 2020). Games also offer complex environments for human-agent collaborations (Fan, Dinculescu, & Ha, 2019). Games have gained increasing attention during recent meetings of the Cognitive Science Society, with presentations on multi-agent collaboration (Wu et al., 2020), foraging (Garg & Kello, 2020) and mastery (Anderson, 2020) (all examples taken from the 2020 Conference).

Goal and scope

The aim of this workshop is to bring together scientists who share a joint interest in using games as a tool to research intelligence. We have invited leading academics from cognitive science who apply games in their research. In particular, our goal is to facilitate discussion about the possibilities and shortcomings of games as research paradigms. Key questions of discussion will include:

- How can games help us to understand human cognition?
- In which research areas could games be useful paradigms?
- What advantages and disadvantages do games have compared with classical experiments?
- What kind of games are useful as research paradigms?
- How can we scale model comparison approaches to big data domains, comparing artificial and biological agents?

Target audience

Our target audience is as interdisciplinary and broad as the conference as a whole — we expect this workshop to be of interest to cognitive psychologists, linguists, developmental psychologists, neuroscientists, computer scientists and machine learning researchers alike. The workshop's webpage can be found at: gamesforintelligence.com

Organizers and presenters

Franziska Brändle (Organizer) is a PhD-student at the Max Planck Institute for Biological Cybernetics. Franziska works on exploration in games, in particular how participants experience fun during learning progress.
Kelsey Allen (Organizer) is a PhD student at MIT. She uses computational models and behavioral experiments to study the development of human action, in particular the interaction between intuitive physics and planning for physical problem-solving contexts.
Joshua B. Tenenbaum (Organizer) is Professor of cognitive science at MIT. Josh's lab sits at the intersection of cognitive science and machine learning, with a focus on hallmarks of human intelligence; in particular, the ability to learn efficiently and flexibly from limited data.

Eric Schulz (Organizer) is Group Leader at the Max Planck Institute of Biological Cybernetics. The research of his lab focuses on how people learn, generalize and explore and includes diverse methods such as interactive games and large datasets.

Wei Ji Ma is Professor of Neuroscience and Psychology at NYU. Broadly, he is interested in decision-making under uncertainty, with a recent focus on planning tasks in which thinking multiple steps ahead is beneficial. He has used a tic-tac-toe variant and *Rush Hour* as experimental paradigms.

Thomas Pouncy is a PhD-student at the Psychology Department of Harvard University. His research focuses on model-based reinforcement learning.

Judith Fan is an Assistant Professor at UC San Diego. Her lab focuses on how people use physical representations of thought to learn, communicate, and solve problems.

Joshua Hartshorne is an Assistant Professor of psychology at Boston College. He is interested in understanding what allows humans, but not current machines, to learn language.

Joshua de Leeuw is an Assistant Professor of cognitive science at Vassar College. His research focuses on the development and application of internet-based tools for the study of human cognition.

Thomas Griffiths is a Professor of psychology and computer science at Princeton University. His research focuses on developing mathematical models of higher-level cognition that underlie our ability to solve everyday problems.

Mark Ho is a Postdoctoral Fellow at Princeton University. His research focuses on the role of meta-reasoning in human problem solving and social cognition.

Özgür Şimşek is a Senior Lecturer in Machine Learning at the University of Bath. Her research is on algorithms that can learn from limited experience in complex, real-word environments, with a focus on reinforcement learning.

Natalia Vélez is a Postdoctoral Fellow at Harvard University. She studies the cognitive capacities and community dynamics that make human collaboration possible.

Alison Gopnik is a Professor of Psychology and Philosophy at UC Berkeley. She studies how children explore and learn about the causal structure of the world, and how this learning allows them to develop intuitive theories.

Workshop structure

We propose a full-day workshop consisting of four parts. The first two parts will be a series of 20 minute talks and 5 minute discussions. Afterward, we will give external speakers the opportunity to present their work in a 45 minute *poster session*. The final 45 minutes will be a *panel discussion*. The first two parts will consist of the following talks:

Presenter	Topic
Ma	Studying complex planning using four-in-a-row
Allen	Physical Reasoning in Games
Pouncy	Structured priors for rule learning in complex environments
Fan	Human-AI Collaborative Games
Hartshorne, de Leeuw	Experiments Subjects Want
Griffiths, Ho	Rationally Representing Games
Tenenbaum	The Frostbite Challenge
Brändle	A Computational Theory of Fun
Şimşek	Bounded Rationality and Games
Vélez	Multigenerational Collaboration in Online Games
Gopnik	Comparing exploration in children and artificial agents in online games

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