Guest Editorial Special Issue on Game Competition Frameworks for Research and Education

GAMES have been widely used to study computational intelligence methods for its highly relevant reflection of real-world problems. They are dynamic, reproducible, cooperative/competitive, and are suitable for testing new machine learning methods or search algorithms. Diverse game competitions have been designed for different research purposes and some of them have been successfully organized for ten years, such as the game Go competition series and PacMan competition series. The past game competitions organized in conferences, industry, or as private leagues have covered various games, including board games, video games, real-time strategy games, first-person shooter game, text-based adventure games, and multiplayer online battle arena. In different competitions, the participants are invited to submit an agent to play a specific game or a set of unknown games at least as good as professional human players, or to submit an agent to design a game or game rules. These have not only received submissions from academic institutions but also attracted the attention of the games industry. Dozens of universities have used different game competition frameworks in modules of game design, artificial intelligence, or machine learning.[1] The aim of this special issue is to highlight some high-quality research and remarkable educational applications using the game competition frameworks.

This special issue received a good number of submissions, not only from the competition organizers but also from the users of the competition frameworks. In total, 12 submissions were finally accepted for publication in this special issue. The accepted papers either describe a competition framework and corresponding competitions, or introduce some algorithms or related research conducted on a game competition framework. Table I lists the frameworks involved in this special issue in alphabetic order. All the mentioned frameworks, their corresponding games, and proposed challenges are diverse and significantly different from each other.

Most of the frameworks mentioned in this special issue focus on one particular game, whereas the General Video Game AI (GVGAI) framework contains more than 100 single-player games, more than 40 two-player games, and offers the functionality of implementing new games thanks to the video game description language. Perez-Liebana *et al.* review the competitions, research, and educational courses based on the GVGAI framework in "General video game AI: A multitrack framework for evaluating agents, games, and content generation algorithms." Five competition tracks with different research aims (planning, learning, and procedural content generation) and challenges have been organized using the GVGAI framework. The single- and two-player planning tracks aim at designing planning algorithms that are capable of playing well on multiple unknown games with the access to game simulations. The learning track provides an excellent framework for testing reinforcement learning algorithms on playing unknown game levels. The level and rule generation tracks raise the challenges of designing new levels for any given game and new rules for any given levels.

Lee *et al.* in "Game data mining competition on churn prediction and survival analysis using commercial game log data" describe a competition on game data mining conducted at the 2017 IEEE Conference on Computational Intelligence and Games (IEEE CIG 2017) using commercial game log data from one of the major game companies in South Korea: NCSOFT. A summary of techniques in use is given. Their datasets are publicly available.

In "StarCraft AI competitions, bots, and tournament manager software," Čertický *et al.* provide an overview of three major annual StarCraft AI competitions, the Student StarCraft AI Tournament, and the competitions organized at the IEEE CIG 2017 and the 2017 Artificial Intelligence and Interactive Digital Entertainment, respectively. The open-source tournament manager software and the bots used in the competitions are also described.

Tavares *et al.* in "Algorithm selection in adversarial settings: From experiments to tournaments in *StarCraft*," propose and investigate an algorithm selection framework to adversarial settings in StarCraft AI tournaments. According to their findings, among a number of selection methods, minimax-Q is the most effective one.

The Visual Doom AI Competition raises the challenge of designing bots that are capable of competing in a multiplayer deathmatch in *Doom*, given raw pixel information only. Wydmuch *et al.* present the first two editions in "ViZDoom competitions: Playing *Doom* from pixels," including the platform, the competition rules and results. The authors conclude that the bots are competent but still worse than human players.

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[1]Reported by the online survey "Game Competitions in Education" (visited on August 25, 2019): https://docs.google.com/document/d/1MXaoJEcxkF_iTFWOoIWNZptXgk0vNa8-T0fosTJYmsQ/edit?usp=sharing.

TABLE I
GAME FRAMEWORKS INTRODUCED OR USED BY THE PUBLICATIONS OF THIS SPECIAL ISSUE

Framework	Game (type)	Task of entries
Deep Learning Othello Competition Framework	Othello (board game)	Game-playing
Dota 2 Bot AI Framework	Dota 2 (multiplayer online battle arena)	Game-playing
FightingICE Platform	FightingICE (fighting game)	Game-playing
Game Data Mining Competition Framework	-	Churn prediction
General Video Game AI (GVGAI) Framework	Video game, puzzle game	Game-playing & PCG
Science Birds	Angry Birds (video game)	PCG
StarCraft AI Tournament Manager	StarCraft (real-time strategy game)	Game-playing
Text-Based Adventure AI Competition Framework	Text-based adventure games	Game-playing
UC-Berkeley Pacman Framework	PacMan (maze arcade game)	Game-playing
ViZDoom RL Research Platform	Doom (first-person shooter game)	Game-playing

"The text-based adventure AI competition," ran by Atkinson *et al.*, is the only competition in this special issue that targets at classic text-based adventure games. Atkinson *et al.* present the implementation details of the open-source framework, the agents in the 2017, 2018, and 2019 competitions, and the results of an improved evaluation of these agents.

Kaneko and Takizawa present in "Computer Shogi tournaments and techniques" two competitions in Shogi (the World Computer Shogi Championship and the Floodgate), as well as some technical contributions by participants and resources for developers.

Another procedural content generation competition is the AIBIRDS Level Generation Competition, in which the submitted agent is required to design new playable Angry Birds levels, given the available block shapes and their characteristics. Stephenson *et al.* present the platform, rules, submitted agents, and results in "The 2017 AIBIRDS level generation competition." This is the only competition that invites human players to judge the agents (via playing through its generated levels) taking into account the "fun level" as one of the evaluation criteria.

In "Dota 2 Bot Competition," Font and Mahlmann present a technical description of the framework for the Dota 2 Bot Competition. This short paper is aimed as a tutorial and promotion for the competition.

Fighting games are challenging mainly due to the unpredictable opponents and possible (combinatorial) actions of the player and his/her opponent. In "Hierarchical reinforcement learning with Monte Carlo tree search in computer fighting game," Pinto and Coutinho describe their agent, combining hierarchical reinforcement learning and Monte Carlo tree search, which is submitted to the Fighting Game Artificial Intelligence (FTGAI) Competition built on top of the FightingICE platform. The agent is trained by playing against the current FTGAI champion, *GigaThunder*, and evaluated by playing against the runners-ups of the competition.

The game-based competition frameworks are also widely used in teaching AI courses and student engagement. In the letter titled "Pacman Capture the Flag in AI courses," Lipovetzky and Sardina describe the use of UC-Berkeley Pacman Capture the Flag Competition as a major assessment component in two large AI courses at RMIT University and the University of Melbourne.

In "Deep Learning Competition framework on Othello for education," Lin *et al.* present the Deep Learning Othello competitions, held in TAAI and TCGA international computer game tournaments in 2017. The competition framework has also been used to motivate undergraduate students to learn deep learning methods in an AI course.

The above briefly introduces the 12 papers in this special issue. We would like to thank the authors and the competition organizers for sharing their valuable work and open-source softwares with us. We would also like to thank the reviewers for providing insightful comments.

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He is currently a Lecturer in computer games and artificial intelligence with the Queen Mary University of London, London, U.K. He has authored/coauthored in the domain of game AI, with interests on reinforcement learning and evolutionary computation. He organized several game AI competitions, such as the Physical Traveling Salesman Problem and the General Video Game AI competitions, held in IEEE conferences. He has authored/coauthored more than 45 papers in the field of game AI, including the main conferences and journals in the field of computational intelligence in games. He has programming experience in the video games industry with titles published for game consoles and PC (http://www.diego-perez.net/).

Tristan Cazenave received the Ph.D. degree in computer science from Sorbonne Université, Paris, France, in 1996. His dissertation was about a system learning to play the game of Go by self play. He is currently a Professor of artificial intelligence at LAMSADE Université Paris-Dauphine, Paris, France. He is the author of more than a hundred scientific papers about artificial intelligence in games. He started to publish commercial video games when he was aged 16 and cofounded a successful web agency in 1992.

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