# General Video Game Artificial Intelligence

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# General Video Game Artificial Intelligence

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## ABSTRACT

Research on general video game playing aims at designing agents or content generators that can perform well in multiple video games, possibly without knowing the game in advance and with little to no specific domain knowledge. The general video game AI framework and competition propose a challenge in which researchers can test their favorite AI methods with a potentially infinite number of games created using the Video Game Description Language. The open-source framework has been used since 2014 for running a challenge. Competitors around the globe submit their best approaches that aim to generalize well across games. Additionally, the framework has been used in AI modules by many higher-education institutions as assignments, or as proposed projects for final year (undergraduate and Master's) students and Ph.D. candidates.

The present book, written by the developers and organizers of the framework, presents the most interesting highlights of the research performed by the authors during these years in this domain. It showcases work on methods to play the games, generators of content, and video game optimization. It also outlines potential further work in an area that offers multiple research directions for the future.

## KEYWORDS

computational intelligence, artificial intelligence, video games, general video game playing, GVGAI, video game description language, reinforcement learning, Monte Carlo tree search, rolling horizon evolutionary algorithms, procedural content generation

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# Preface

General video game AI (GVGAI) was originally inspired by one of the previous works carried out at a Dagstuhl seminar in 2013, in which a group of researchers played with the idea of defining a language for video games and building a framework (and competition) around it for agents to play these games. The original ideas outlined in this work (general video game playing, game classification, game tuning and game generation) have materialized over the years in concrete software, general approaches, research projects and an international competition.

The GVGAI framework and competition were born at the University of Essex (UK) in 2014. Previous experience of organizing competitions at this University made the Game Intelligence Group a perfect environment to start. Spyridon Samothrakis, Simon M. Lucas, and Diego Pérez Liébana kick-started then this ambitious project, in collaboration with Julian Togelius (then at ITU Copenhagen, Denmark) and Tom Schaul (then at New York University, U.S.), who developed the first engine for the video game description language (VGDL) in Python. The GVGAI competition was held for the first time in 2014 at the IEEE Conference on Computational Intelligence and Games. Since that first edition, focused on planning agents playing a total of 30 different games, the *GVGAI world* has kept growing. On July 2019, the framework counts on 200 games and 5 different competition tracks. Raluca D. Gaina joined the team to bring the 2-Player track, Ahmed Khalifa brought the Procedural Content Generation challenges and Jialin Liu led the (repeatedly requested) learning track. Since 2014, more than 200 students and researchers around the globe have submitted agents and generators to the challenge, and several high-level education institutions have used GVGAI to propose assignments and student projects at different levels (undergraduate, master and Ph.D.). A recent survey on GVGAI cites around 100 papers that use GVGAI for research.

This book is a summary of our work on GVGAI for the last five years. This book presents the main components of GVGAI, from the video game description language (VGDL) used to generate games to the framework itself and the multiple opportunities for research it presents. The book is also a collection of what is, in our opinion, our most relevant work on this domain and dives deep into optimization and control algorithms. Finally, multiple exercises and project ideas are proposed at the end of each chapter as suggestions to take this research further.

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# Acknowledgments

During these five years of GVGAI work, we have had the pleasure to collaborate with many people on this challenge. A special mention needs to be made to our multiple co-authors during these years. Spyridon Samothrakis and Tom Schaul, members of the GVGAI steering committee, played a crucial role defining the shape of the challenge and competition at the start. Philip Bontrager and Ruben Torrado implemented the GVGAI-Gym version of the framework for the learning track of the competition. Sanaz Mostaghim's expertise on multi-objective Optimization and Kamolwan Kunanusont's work on game optimisation also contributed to the research presented in this book.

We would also like to thank Adrien Couëtoux, Dennis Soemers, Mark Winands, Tom Vodopivec, Florian Kirchgessner, Jerry Lee, Chong-U Lim and Tommy Thompson. They built the first set of GVGAI agents that were used for testing the framework, both the single and the two-player planning tracks of the competition. Thanks also go to Cameron Browne and Clare Bates Congdon for their read, review and useful comments made to improve this book.

Finally, we would also like to thank the Game AI community that has shown interest in this challenge. Thanks to the members of the group at the 2013 Dagstuhl seminar on "Artificial and Computational Intelligence in Games," the instructors that have used GVGAI for setting assignments for their modules and the participants that have submitted a controller or a generator to the competition.

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