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Advances in Computer Games

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Revised Papers

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Preface

This book contains the papers of the 12th Advances in Computer Games Conference (ACG 2009) held in Pamplona, Spain. The conference took place during May 11–13, 2009 in conjunction with the 13^{th} Computer Olympiad and the 16^{th} World Computer Chess Championship.

The Advances in Computer Games conference series is a major international forum for researchers and developers interested in all aspects of artificial intelligence and computer game playing. The Pamplona conference was definitively characterized by fresh ideas for a large variety of games.

The Program Committee (PC) received 41 submissions. Each paper was initially sent to at least three referees. If conflicting views on a paper were reported, it was sent to an additional referee. Out of the 41 submissions, one was withdrawn before the final decisions were made. With the help of many referees (see after the preface), the PC accepted 20 papers for presentation at the conference and publication in these proceedings.

The above-mentioned set of 20 papers covers a wide range of computer games. The papers deal with many different research topics. We mention: Monte-Carlo Tree Search, Bayesian Modeling, Selective Search, the Use of Brute Force, Conflict Resolution, Solving Games, Optimization, Concept Discovery, Incongruity Theory, and Data Assurance.

The 17 games that are discussed are: Arimaa, Breakthrough, Chess, Chinese Chess, Go, Havannah, Hex, Kakuro, k-in-a-Row, Kriegspiel, LOA, 3 x n AB Games, Poker, Roshambo, Settlers of Catan, Sum of Switches, and Video Games.

We hope that the readers will enjoy the research efforts performed by the authors. Below we provide a brief characterization of the 20 contributions, in the order in which they are published in the book.

"Adding Expert Knowledge and Exploration in Monte-Carlo Tree Search," by Guillaume Chaslot, Christophe Fiter, Jeap-Baptiste Hoock, Arpad Rimmel, and Oliver Teytaud, presents a new exploration term, which is important in the trade-off between exploitation and exploration. Although the new term improves the Monte-Carlo Tree Search considerably, experiments show that some important situations (semeais, nakade) are still not solved. Therefore, the authors offer three other important improvements. The contributions is a joy to read and provides ample insights into the underlying ideas of the Go program MoGo.

"A Lock-Free Multithreaded Monte-Carlo Tree Search Algorithm" is authored by Markus Enzenberger and Martin Müller. The contribution focuses on efficient parallelization. The ideas on a lock-free multithreaded Monte-Carlo Tree Search aim at taking advantages of the memory model of the AI-32 and Intel-64 CPU architectures. The algorithm is applied in the Fuego Go program and has improved the scalability considerably.

"Monte-Carlo Tree Search in Settlers of Catan," by Ostván Szita, Guillaume Chaslot, and Pieter Spronck, describes a successful application of MCTS in multi-player strategic decision making. The authors use the non-deterministic board game Settlers of Catan for their experiments. They show that providing a game-playing algorithm with (limited) domain knowledge can improve the playing strength substantially. Two techniques that are discussed and tested are: (1) using non-uniform sampling in the Monte-Carlo simulation phase and (2) modifying the statistics stored in the game tree.

"Evaluation Function-Based Monte-Carlo LOA" is written by Mark H.M. Winands and Yngvi Björnsson. The paper investigates how to use a positional evaluation function in a Monte-Carlo simulation-based LOA program (ML-LOA). Four different simulations strategies are designed: (1) Evaluation Cutt-Off, (2) Corrective, (3) Greedy, and (4) Mixed. Experimental results reveal that the Mixed strategy is the best among them. This strategy draws the moves randomly based on their transition probabilities in the first part of a simulation, but selects them based on their evaluation score in the second part of a simulation.

"Monte-Carlo Kakuro" by Tristan Cazenave is a one-person game that consists in filling a grid with integers that sum up to predefined values. Kakuro can be modeled as a constraint satisfaction problem. The idea is to investigate whether Monte-Carlo methods can improve the traditional search methods. Therefore, the author compares (1) Forward Checking, (2) Iterative Sampling and (3)Nested Monte-Carlo Search. The best results are produced by Nested Monte-Carlo search at level 2.

"A Study of UCT and Its Enhancements in an Artificial Game" is authored by David Tom and Martin Müller. The authors focus on a simple abstract game called the Sum of Switches (SOS). In this framework, a series of experiments with UCT and RAVE are performed. By enhancing the algorithm and fine-tuning the parameters, the algorithmic design is able to play significantly stronger without requiring more samples.

"Creating an Upper-Confidence Tree Program for Havannah, " by F. Teytaud and O. Teytaud, presents another proof of the general applicability of MCTS by testing the techniques on the Havannah game. The authors investigate Bernstein's formula, the success role of UCT, the efficiency of RAVE, and progressive widening. The outcome is quite positive in all four subdomains.

"Randomized Parallel Proof-Number Search," by Jahn Takeshi Saito, Mark H.M. Winands, and H.Jaap van den Herik, describes a new technique for parallelizing Proof Number Search (PNS) on multi-core systems with shared memory. The parallelization is based on randomizing the move selection of multiple threats, which operate on the same search tree. Experiments show that RP-PNS scales well. Four directions for future research are given.

"Hex, Braids, the Crossing Rule and XH-Search," written by Philip Henderson, Broderik Arneson, and Ryan B. Hayward, proposes XH-search, a Hex connection finding algorithm. XH-search extends Anshelevich's H-search by incorporating a new crossing rule to find braids, connections built from overlapping subconnections. XH-search is efficient and easily implemented.

"Performance and Prediction: Bayesian Modelling of Fallible Choice in Chess" is a contribution by Guy Haworth, Ken Regan, and Giuseppe Di Fatta. The authors focus on the human factor as is evidently expressed in games, such as Roshambo and Poker. They investigate (1) assessing the skill of a player, and (2) predicting the behavior of a player. For these two tasks they use Bayesian inferences. The techniques so developed enable the authors to address hot topics, such as the stability of the rating scale, the comparison of players of different eras, and controversial incidents possibly involving fraud. The last issue, for instance, discusses clandestine use of computer advice during competitions.

"Plans, Patterns and Move Categories Guiding a Highly Selective Search" written by Gerhard Trippen. New ideas for an Arimaa-playing program RAT are presented. RAT starts with a positional evaluation of the current position. A directed position graph based on pattern matching decides which plan of a given set of plans should be followed. The plan then dictates what types of moves can be chosen. Leaf nodes are evaluated only by a straightforward material evaluation. The highly selective search looks, on average, at only five moves out of 5,000 to over 40,000 possible moves in a middle game position.

"6-Man Chess and Zugzwangs" by Eiko Bleicher and Guy Haworth. They review zugzwang positions where having the move is a disadvantage. An outcome of the review is the observation that the definition of *zugzwang* should be revisited, if only because the presence of *en passent capture* moves gives rise to three, new, asymmetric types of zugzwang. With these three new types, the total number of types is now six. Moreover, there are no other types.

"Solving Kriegspiel Endings with Brute Force: The Case of KR vs K" is a contribution by Paolo Ciancarini and Gian Piero Favini. The paper proposes the solution of the KRK endgame in Kriegspiel. Using brute force and a suitable data representation, one can achieve perfect play, with perfection meaning fastest checkmate in the worst case and without making any assumptions on the opponent. The longest forced mate in KRK is 41. The KRK tablebase occupies about 80 megabytes of hard disk space. On average, the program has to examine 25,000 metapositions to find the compatible candidate with the shortest route to mate.

"Conflict Resolution of Chinese Chess Endgame Knowledge Base," written by Bon-Nian Chen, Pangfang Liu, Shun-Chin Hsu, and Tsan-sheng Hsu, proposes an autonomic strategy to construct a large set of endgame heuristics, which help to construct an endgame database. A conflict resolution strategy eliminates the conflicts among the constructed heuristic databases. The set of databases is called *endgame knowledge base*. The authors experimentally establish that the correctness of the constructed endgame knowledge base so obtained is sufficiently high for practical use.

"On Drawn k-in-a-Row Games," by Sheng-Hao Chiang, I-Chen Wu, and Ping-Hung Lin, continues the research on a generalized family of k-in-a-row games. The paper simplifies the family to *Connect (k, p)*. Two players alternately place p stones on empty squares of an infinite board in each turn. The player who first obtains k connective stones of the own color horizontally, vertically, or diagonally wins the game. A *Connect*(k, p) game is drawn if both players have no winning strategy. Given p, the authors derive the value $k_{draw}(p)$, such that *Connect*$(k_{draw}(p),\ p)$ is drawn, as follows. (1) k_{draw} (2)=11. (2) For all $p \geq 3$, $k_{draw}(p)= 3p + 3d + 8$, where d is a logarithmic function of p. So, the ratio $k_{draw}(p)/p$ is approximate to 3 for sufficiently large p. To their knowledge, the $k_{draw}(p)$ are currently the smallest for all $2 \leq p < 1000$, except for p=3.

"Optimal Analyses for 3 × n AB Games in the Worst Case," is written by Li-Te Huang and Shun-Shii Lin. The paper observes that by the complex behavior of deductive genes, tree-search approaches are often adopted to find optimal strategies. In the paper, a generalized version of deductive games, called $3 \times n$ AB games, is introduced. Here, traditional tree-search approaches are not appropriate for solving this problem. Therefore a new method is developed called *structural reduction.* A worthwhile formula for calculating the optimal numbers of guesses required for arbitrary values of n is derived and proven to be final.

Automated Discovery of Search-Extension Features is a contribution by Pálmi Skowronski, Yngvi Björnsson, and Mark H.M. Winands. The authors focus on selective search extentions. Usually, it is a manual trial-and-error task. Automating the task potentially enables the discovery of both more complex and more effective move categories. The introduction of *Gradual Focus* leads to more refined new move categories. Empirical data are presented for the game Breakthrough, showing that Gradual Focus looks at a number of combinations that is two orders of magnitude fewer than a brute-force method, while preserving adequate precision and recall.

"Deriving Concepts and Strategies from Chess Tablebases," by Matej Guid, Martin Možina, Aleksander Sadikov, and Ivan Bratko, is an actual AI challenge. A positive outcome on the human understandability of the concepts and strategies would be a milestone. The authors focus on the well-known KBNK endgame. They develop an approach that combines specialized minimax search with argument-based machine learning (ABML). In the opinion of chess coaches who commented on the derived strategy, the tutorial presentation of this strategy is appropriate for teaching chess students to play this ending.

"Incongruity-Based Adaptive Game Balancing" is a contribution by Giel van Lankveld, Pieter Spronck, Jaap van den Herik, and Matthias Rauterberg. The authors focus on the entertainment value of a game for players of different skill levels. They investigate a way of automatically adopting a game's balance. The idea of adopting the balance is based on the theory of incongruity. The theory is tested for three difficult settings. Owing to the implementation of this theory it can be avoided that a game becomes *boring* or *frustrating.*

"Data Assurance in Opaque Computations," by Joe Hurd and Guy Haworth, examines the correctness of endgame data for multiple perspectives. The issue of defining a data model for a chess endgame and the systems engineering responses to that issue are described. A structured survey has been carried out of the intrinsic challenges and complexity of creating endgame data by reviewing (1) the past pattern of errors, (2) errors crept in during work in progress, (3) errors surfacing in publications, and (4) errors occurring after the data were generated. Three learning points are given.

This book would not have been produced without the help of many persons. In particular, we would like to mention the authors and the referees for their help. Moreover, the organizers of the three events in Pamplona (see the beginning of this preface) have contributed substantially by bringing the researchers together. Without much emphasis, we recognize the work by the committees as essential for this publication. Finally, the editors happily recognize the generous sponsors Gobierno de Navarra, Ayuntamiento de Pamplona Iruñeko Udala, Centro Europeo de Empresas e Innovación Navarra, ChessBase, Diario de Navarra, Federación Navarra de Ajedrez, Fundetec, ICGA, Navarmedia, Respuesta Digital, TiCC (Tilburg University), and Universidad Pública de Navarra.

January 2010

Jaap van den Herik
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