Knowledge-Based Systems 34 (2012) 1–2

Contents lists available at SciVerse ScienceDirect

Knowledge-Based Systems

journal homepage: www.elsevier.com/locate/knosys

Editorial

A special issue on artificial intelligence in computer games: AICG

The research on computer games has been one of the most important areas in artificial intelligence since Shannon designed programs to play Chess in 1950. The realm related to computer games includes computational intelligence, algorithms, cognitive science, machine learning, software engineering and combinatorial game theory. Recently, researchers in the area of computer games have made significant progresses in the following two aspects. First, many challenging new games are proposed, such as Amazon, Havannah, and Connect6. Second, Monte Carlo Tree Search (MCTS) is proposed to make a significant breakthrough, especially on Go. Many Go programs with MCTS such as Crazy Stone, MoGo, Zen, Fuego, Many Faces of Go, Erica and Pachi achieved a level that was incredible only a decade ago. These programs are now competitive at a grand master level for 9×9 Go, and with a 5–6 stone handicap for 19×19 Go.

In this special issue, we have gathered a group of high quality papers on some of the hottest topics in computer games. In addition to MCTS in many aspects, the topics collected in this special issue also include knowledge representation models for computer games, current state of arts of game-playing programs for challenging games, combinatorial game theory, applying ontologies, evolutionary computation, and fuzzy logic to games, social network games, and online games.

"Single-Player Monte-Carlo Tree Search for SameGame", by Maarten P.D. Schadd, Mark H.M. Winands, Mandy J.W. Tak, and Jos W.H.M. Uiterwijk, presents MCTS for a Single-Player game, named SameGame. Classical methods such as A* and IDA* are popular and successful choices for one-player games. However, they would fail without an accurate admissible evaluation function. For Single-Player games without the functions, this paper proposes a new MCTS variant, called Single-Player Monte Carlo Tree Search (SP-MCTS), an interesting alternative for one-player games. The selection and back propagation strategies in SP-MCTS are different from standard MCTS. It turned out that the SP-MCTS program is able to score a substantial number of points on the standardized test set.

"Nested Monte-Carlo Search with Simulation Reduction", by Haruhiko Akiyama, Kanako Komiya, and Yoshiyuki Kotani, presents a nested MCTS algorithm for Morpion Solitaire, a single-player game. This paper investigates two methods for reducing the execution time in order to enable a deeper nested search, and simply reducing the number of lower level searches by a constant rate and using all-moves-as-first heuristic to the reduction in the number of lower level searches. The experiment shows that the latter is more effective. Using it, this paper achieves a new world record of 146 moves for Morpion Solitaire.

"Dynamic Randomization and Domain Knowledge in Monte-Carlo Tree Search for Go", by Keh-Hsun Chen, presents proposes two dynamic randomization techniques for MCTS in Go. First, during the in-tree phase of a simulation game, the parameters are randomized in selected ranges before each simulation move. Second, during the play-out phase, the priority orders of the simulation move-generators are hierarchically randomized before each play-out move. Essential domain knowledge used in MCTS for Go is discussed. Both dynamic randomization techniques increase diversity while keeping the sanity of the simulation games. The experimental results on his Go program, GoIntellect, show that dynamic randomization increases the playing strength of GI significantly – with 128 K simulations per move, the improvement is about 7% in the winning rate against GnuGo on 19×19 Go without dynamic randomization, about 3% on 13×13 Go, and 4% on 9×9 Go.

"UCD: Upper Confidence bound for rooted Directed acyclic graphs", by Abdallah Saffidine, Tristan Cazenave, and Jean Méhat, presents a framework for testing various algorithms that deal with transpositions in Monte-Carlo Tree Search (MCTS). This framework is called Upper Confidence bound for Direct acyclic graph (UCD) as it constitutes an extension of Upper Confidence bound for Trees (UCT) for Direct Acyclic Graph (DAG). When using transpositions in MCTS, a DAG is progressively developed instead of a tree. There are multiple ways to handle the exploration exploitation dilemma when dealing with transpositions. This paper proposes parameterized ways to compute the mean of the child, the playouts of the parent and the playouts of the child, and tests the resulting algorithms on several games. For all games, original configurations of the proposed algorithms improve on state of the art algorithms.

"Aggregating Consistent Endgame Knowledge in Chinese Chess", by Bo-Nian Chen, Pang-Feng Liu, Shun-Chin Hsu, and Tsan-sheng Hsu, discusse to aggregate Consistent Endgame Knowledge in Chinese Chess. In order to aggregate endgame knowledge effectively, this paper proposes a Chinese Chess endgame knowledge-based system to construct a large set of consistent endgame heuristics, called endgame knowledge base, used in their program, Contemplation. The knowledge-based system consists of the acquisition module, the inference module, the inquiry module and the verification module. This system implements a graph model that has the functionality of maintaining consistency and improving its correctness. The experimental results on self-play test show that the playing strength of Contemplation has a distinct enhancement with this knowledge base.

"Bitboard Knowledge Base System and Elegant Search Architectures for Connect6", Jung-Kuei Yang, Shi-Jim Yen, Tai-Ning Yang, and Kuo-Yuan Kao presents an efficient search program for Connect6. First, this paper increases the search efficiency of Connect6 programs by encoding connection patterns and computing the inherent information in a bitboard knowledge base system in

0950-7051/$ - see front matter © 2012 Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.knosys.2012.05.014

advance. This paper also proposes a method of generating threat moves and a method of the search, called Multistage Proof Number Search. The search method improves the performance by developing candidate moves in stages according to their importance.

"XT Domineering: A New Combinatorial Game", by Kuo-Yuan Kao, I-Chen Wu, and Yi-Chang Shan, introduces a new combinatorial game, named XT Domineering, together with its mathematical analysis. XT Domineering is modified from the Domineering game, in which 1×2 or 2×1 dominos are allowed to be placed on empty squares in an $m \times n$ board. This new game allows a player to extensively place a 1×1 domino on an empty square s while unable to place a 1×2 or 2×1 domino in the connected group of empty squares that includes s. After modifying the rule, each position in the game becomes an infinitesimal. This paper calculates the game values of all sub-graphs of 3×3 squares and shows that each sub-graph of 3×3 squares is a linear combination of eight elementary infinitesimals. These pre-stored game values can be viewed as a knowledge base for playing XT Domineering. Instead of searching the whole game trees, a simple rule for determining the optimal outcome of any sum of these positions is presented.

"Genetic Fuzzy Markup Language for Game of NoGo", by Chang Shing Lee, Mei-Hui Wang, Yu-Jen Chen, Hani Hagras, Meng-Jhen Wu, and Olivier Teytaud, presents an approach combining the technologies of ontologies, evolutionary computation, fuzzy logic, fuzzy markup language (FML) with a genetic algorithm (GA)-based system for the NoGo game. Based on the collected patterns and the pre-constructed fuzzy NoGo ontology, the genetic FML (GFML) is able to analyze the situation of the current game board and then play next move to an inferred good-move position. Additionally, the genetic learning mechanism continuously evolves the adopted GFMLs to enable an increase in the winning rate of the GA-based NoGo via playing with the baseline NoGo. The acquired winning rates at the time series show that the proposed approach can work effectively and that the average winning rate of the GA-based NoGo program is much stronger than the baseline NoGo program.

"Trajectory Analysis for User Verification and Recognition", by Hsing-Kuo Pao, Junaidillah Fadlil, Hong-Yi Lin, and Kuan-Ta Chen, presents a trajectory analysis for user verification and recognition on online games. The objective of verification is to separate genuine account owners from intruders or miscreants. This paper proposes a general user verification approach based on user trajectories. A trajectory consists of a sequence of coordinated inputs. Several kinds of trajectories are studied, including online game traces, mouse traces, handwritten characters, and traces of the movements of animals in their natural environment. The proposed method is designed to prevent the possible copying or duplication of information by unauthorized users or automatic programs, such as bots. The method can also be applied to the task of recognition, and used to predict the type of trajectory without the user's predefined identity. The experiment results demonstrate that the proposed method can perform better or is competitive to existing state-of-the-art approaches for both of the verification and recognition tasks.

"Game Team Balancing by Using Particle Swarm Optimization", by Shih-Wei Fang and Sai-Keung Wong, proposes a novel system, team ability balancing system (TABS), which is developed for automatically evaluating the performance of two teams in a role-playing video game. TABS can be used for assisting game designers to improve team balance. In TABS, artificial neural network (ANN) controllers learn to play the game in an unsupervised manner and they are evolved by using particle swarm optimization. The ANN controllers control characters of the two teams to fight with each other. An evaluation method is proposed to evaluate the performance of the two teams. Based on the evaluation results, the game designers can adjust the abilities of the characters so as to achieve team balance. This paper demonstrates TABS for the game MagePowerCraft in which each team consists of up to three characters.

"Improving Game Bot Behaviors through Timed Emotional Intelligence", Giovanni Acampora, Vincenzo Loia and Autilia Vitiello, presents innovative computational intelligence techniques to provide game bots with human-like capabilities and improve the realism of game under design. The techniques, such as the Timed Automata based Fuzzy Controllers, have been hybridized with emotional representation methodologies. In order to allow different competitors to exploit the "emotional engine" on different hardware platforms, the Fuzzy Markup Language (FML) has been chosen as main technology for designing and implementing the bots behavior. As will be shown in a case study based on Unreal Tournament 2004, the game bots exploiting the approach provide a more human-likeness behavior if compared with simple finite state automaton based bots.

"An analytical model for generalized ESP games", by Bo-Chun Wang, Chien-Wei Lin, Kuan-Ta Chen and Ling-Jyh Chen, presents an analytical model for generalized ESP games. The ESP game, a kind of Games With A Purpose (GWAP), leverages people's desire to be entertained and also outsource certain steps of the computational process to humans. This paper shows that the proposed model can accurately predict the stopping condition that will yield the optimal utility of a generalized ESP game under a specific game setting. A service provider can therefore utilize the model to ensure that the hosted generalized ESP games produce high-quality labels efficiently. This paper also proposes a metric, called system gain, for evaluating the performance of ESP-like GWAP systems, and also uses analysis to study the properties of generalized ESP games. This paper implements an optimal puzzle selection strategy (OPSA) based on the analysis, and demonstrates that the proposed OPSA approach can effectively improve the system gain of generalized ESP games, as long as the number of puzzles in the system is sufficiently large.

Hamido Fujita
Faculty of Software and Information Science,
Iwate Prefectural University,
152-52 Sugo, Takizawa,
Iwate 020-0193, Japan
E-mail address: issam@iwate-pu.ac.jp

I-Chen Wu
Department of Computer Science,
National Chiao Tung University,
1001 Ta-Hsueh Road,
Hsinchu, Taiwan

Available online 26 May 2012