Game Design in the Age of AI

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THE big news in the game AI community recently has been the victory of Google DeepMind's ALPHAGO program [1] over top professional Go player Lee Sedol. 19×19 Go is a notoriously difficult game and was seen by many researchers as the holy grail of game AI. Such a victory was not expected for years to come, but it is now clear that computers outperform humans in almost all games of strategy to which they have been applied.

So what effect will such superhuman AI performance have on the games that we design? My answer is: *little, if any*. Note that I am talking about AI for *playing* games, not AI for *designing* games; that is a whole other can of worms, to be addressed in future issues.

Superhuman AI

Since its inception, the field of AI has been inextricably linked with the study of games. Games of pure strategy provide a convenient litmus test for the sophistication of AI approaches, and there has been a constant drive by researchers to outperform previous results on increasingly complex games. One by one we have seen them topple, starting with simple games such as Tic-Tac-Toe, Connect Four, Go-Moku, Nine Men's Morris, to more notable successes of recent years including Chess, Draughts and now 19×19 Go.

There is an important distinction between actually *solving* a game and playing it at a superhuman level. Chess and Go have not been solved, but computer players are now so strong that the distinction becomes less important in practical terms; a human playing against a computer will lose. Affordable Chess programs that run on standard desktop machines now exceed the strength of DEEP BLUE when it famously defeated Kasparov in 1997 and even smartphone apps now play Chess at Grandmaster level.

The game Arimaa was designed specifically to defeat computer players. However, superhuman AI performance was recently achieved even for this game, using standard alpha-beta tree search methods over half a century old [2].

This trend is also true for puzzle games, even nondeterministic ones. Consider the game 2048, in which players slide numbered tiles around a grid such that matching tiles which overlap merge to double their value, while a random tile is inserted with each move. A competent human player will typically achieve the titular 2048 tile and a score in the vicinity of 50,000 points, but an AI recently put such efforts to shame, achieving a 32768 tile and a score of 839,732.[1]

The game of Pylos is an interesting case. While developing an autonomous robot player for Pylos, Aichholzer *et al.* [3] solved the game by generating a database of all possible positions, from each of which a winning line can be forced if it exists. This will of course defeat any human player, but only if this database of positions (which occupies 30GB of storage) is accessible. Its AI uses a dumb brute force approach with no strategic understanding of the game, which I believe is the crux of the issue.

A criticism of DEEP BLUE was that its strength stemmed from then state-of-the-art hardware, and clever algorithms by its programmers, rather than any inherent strategic understanding of Chess. Similarly, the landmark performance of ALPHAGO was achieved through a clever combination of two 'black box' methods – artificial neural networks and Monte Carlo tree search – to produce strong moves that neither the program, nor its programmers, nor its opponents, really understood. It is this missing element of strategic analysis that keeps games interesting for humans.

Jonathan Schaeffer points out that just because a game can be solved does not mean that it is a bad game [4]: *'What makes a game fun? Intellectual challenge, social aspects, simplicity of the rules, aesthetics... many things.'* Herik *et al.* [5] observe that a game's susceptibility to computer solution depends more on its *decision complexity* than its *computational complexity*. Decision complexity is related to the strategic depth of a game, which is a vital part of what keeps games interesting for us even after repeated plays.

There is no denying that computer players now outperform us at most games of strategy. But this does not necessarily affect our enjoyment of these games against other human players, only against overly strong AI opponents. A game is only ruined if a winning strategy can be formulated in such a way that the human brain can understand and exploit it, without the need for powerful computers or extensive databases. I reiterate my claim that superhuman AI performance should have little impact on the games that we

[1] http://www.randalolson.com/2015/04/27/artificial-intelligence-has-crushed-all-human-records-in-2048-heres-how-the-ai-pulled-it-off/

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design, if any, provided that those games are designed to be played *by* humans *against* humans.[2]

This Issue

This issue covers a range of game types: strategy, war, dice, card and role-playing games; and logic and physical puzzles. We again lead with a piece by Carl Hoff, who again provides the eye-catching front cover image. Carl's article 'Wrap O-round Weave Five' describes his motivation for designing a physical puzzle ring with an interlocking weave around its entire circumference, and how he went about achieving this goal with his 'WOW5' ring. This work demonstrates the use of computers to assist the manual design process, rather than their more usual application as combinatorial number-crunchers.

Jimmy Goto and Yuka Miyagi then describe the logic puzzle 'Shakashaka', and how its designer's search for beauty and complexity inadvertently captured a style of mathematical artwork from the 1700s. Shakashaka is this issue's 'feature puzzle', and you will find sample challenges printed throughout, in order of difficulty. Thanks to Nikoli for providing these challenges.

In 'Eco-Friendly Game Design', Néstor Romeral Andrés and I show how off-cuts from the manufacture of game components can be *upcycled* into new games rather than thrown out as waste. This is demonstrated through several examples from Néstor's catalogue of games.

For their piece 'Characterising Score Distributions in Dice Games', Aaron Isaksen and colleagues use computer analysis to model the effect of different combinations of dice on simulated combat results in dice-based games. They demonstrate that subtle differences in the dice used can have a significant effect on game balance, and discuss how to find the right combination of dice to achieve desired in-game behaviours.

Spyridon Samothrakis then offers a system for classifying role-playing games, based on their game-theoretic outcomes, in 'Narrative Progression Traits for Role-Playing Games'. He suggests the use of *narrative progression traits* to help design balanced, interesting new role-play games, based on this classification scheme.

My own article 'Bug or Feature?' returns to the computational theme, with a somewhat programmatic approach to game design as an optimisation problem. I demonstrate through example how apparent design *bugs* can sometimes be recognised as positive *features* when fully understood, and how actual bugs can often be turned into useful features with simple rule tweaks.

F. Miguel Marqués offers a personal view of how combat mechanisms in war games have evolved over the years to become more elegant and user-friendly, in 'Elegant Combat in War Games'. Miguel describes ways of simulating the 'fog of war' with abstract rules, and extols the virtues of the 'design for effect' approach.

Daniel Ashlock's first instalment in the *Maths in Games* column, 'Graph Theory in Game and Puzzle Design', demonstrates how most games and puzzles played on boards or maps can be decomposed into mathematical graphs. He explores the relationships between games, puzzles and graphs through several examples, and how this can be used to design new games.

Connor Bell and Mark Goadrich's article 'Automated Playtesting with RECYCLEd CARDSTOCK' introduces the RECYCLE language for describing card games. They contribute to the research topic of AI for game design by providing a computer system for modelling card games, automatically evaluating them for quality, and assisting the user in designing new games.

This issue concludes with a reprint of Robert Abbott's classic piece 'Under the Strategy Tree' and its later addendum. The addendum is of special note in the annals of game design, as this is where Abbott pretty much nails the concepts of *clarity* and *depth*, and the relationship between the two, in three simple sentences.

References

[1] Silver, D., *et al.*, 'Mastering the Game of Go with Deep Neural Networks and Tree Search', *Nature*, vol. 529, no. 7587, 2016, pp. 484–489.

[2] Wu, D. J., 'Designing a Winning Arimaa Program', *ICGA Journal*, vol. 38, no. 1, pp. 19–40.

[3] Aichholzer, O., Detassis, D., Hackl, T., Steinbauer, G. and Thonhause, J., 'Playing Pylos with an Autonomous Robot', *Intelligent Robots and Systems (IROS)*, Taipei, IEEE Press, 2010, pp. 2507–2508.

[4] Rigney, R., 'You May Win Every Time, But You Haven't Solved This Game Yet', *Wired*, 11 December 2012. http://www.wired.com/2012/11/letterpress-solved-games/

[5] van den Herik, H. J., Uiterwijk, J. W. H. M. and van Rijswijck, J., 'Games Solved: Now and in the Future', *Artificial Intelligence*, vol. 134, no. 1–2, 2002, pp. 277–311.

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[2]This discussion neatly side-steps the tangential question of what it will actually mean to be 'human', when the brain/machine interface develops to such an extent that we become superhuman ourselves.