Home * Engines * **AlphaZero**

The Krampus has come [3] [4]

AlphaZero,
a chess and Go playing entity by Google DeepMind based on a general reinforcement learning algorithm with the same name. On December 5, 2017, the DeepMind team around David Silver, Thomas Hubert, and Julian Schrittwieser along with former Giraffe author Matthew Lai, reported on their generalized algorithm, combining Deep learning with Monte-Carlo Tree Search (MCTS) [1] .

A 100 game match versus Stockfish 8 using 64 threads and a transposition table size of 1GiB, was won by AlphaZero using a single machine with 4 Tensor processing units (TPUs) with +28=72-0. Despite a possible hardware advantage of AlphaZero and criticized playing conditions [2], this seems a tremendous achievement.

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Description

Starting from random play, and given no domain knowledge except the game rules, AlphaZero achieved a superhuman level of play in the games of chess and Shogi as well as in Go. The algorithm is a more generic version of the AlphaGo Zero algorithm that was first introduced in the domain of Go [5] . AlphaZero evaluates positions using non-linear function approximation based on a deep neural network, rather than the linear function approximation as used in classical chess programs. This neural network takes the board position as input and outputs a vector of move probabilities. The MCTS consists of a series of simulated games of self-play whose move selection is controlled by the neural network. The search returns a vector representing a probability distribution over moves, either proportionally or greedily with respect to the visit counts at the root state.

Network Architecture

The network is a deep residual convolutional neural network [6] [7] with many layers of spatial NxN planes - 8x8 board arrays for chess. The input describes the chess position from side's to move point of view - that is color flipped for black to move. Each square cell consists of 12 piece-type and color bits, e.g. from the current bitboard board definition, and to address graph history and path-dependency - times eight, that is up to seven predecessor positions as well - so that en passant, immediate repetitions, or some sense of progress is implicit. Additional inputs, redundant inside each square cell to be conform to the convolution net, consider castling rights, halfmove clock, total move count and side to move.

The deep hidden layers connect the pieces on different squares to each other due to consecutive 3x3 convolutions, where a cell of a layer is connected to the correspondent 3x3 receptive field of the previous layer, so that after 4 layers, each square is connected to every other cell in the original input layer [8]. The output of the neural network is finally represented as an 8x8 board array as well, for every origin square up to 73 target square possibilities (NRayDirs x MaxRayLength + NKnightDirs + NPawnDirs *

NMinorPromotions), encoding a probability distribution over 64x73 = 4,672 possible moves, where illegal moves were masked out by setting their probabilities to zero, re-normalising the probabilities for remaining moves.

Training

AlphaZero was trained in 700,000 steps or mini-batches of size 4096 each, starting from randomly initialized parameters, using 5,000 first-generation TPUs [9] to generate self-play games and 64 second-generation TPUs [10] [11] [12] to train the neural networks [13] .

See also

- Alpha-Beta
- Alpha I
- AlphaGo
- Chess Engines with Neural Networks
- Learning Chess Programs
- LCZero

Publications

- David Silver, Julian Schrittwieser, Karen Simonyan, Ioannis Antonoglou, Aja Huang, Arthur Guez, Thomas Hubert, Lucas Baker, Matthew Lai, Adrian Bolton, Yutian Chen, Timothy Lillicrap, Fan Hui, Laurent Sifre, George van den Driessche, Thore Graepel, Demis Hassabis (**2017**). Mastering the game of Go without human knowledge. Nature, Vol. 550, pdf
- David Silver, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez , Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, Demis Hassabis (**2017**). *Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm*. arXiv:1712.01815

Forum Posts

2017

- Google's AlphaGo team has been working on chess by Peter Kappler, CCC, December 06, 2017
- Historic Milestone: AlphaZero by Miguel Castanuela, CCC, December 06, 2017
- AlphaZero beats AlphaGo Zero, Stockfish, and Elmo by Carl Lumma, CCC, December 06, 2017
- AlphaZero vs Stockfish by Bigler, CCC, December 06, 2017
- Deepmind drops the bomb by Leebot, FishCooking, December 06, 2017
- AlphaZero beats Stockfish 8 by 64-36 by Venator, Rybka Forum, December 06, 2017

- Alpha Zero by BB+, OpenChess Forum, December 06, 2017
- AlphaGo Zero And AlphaZero, RomiChess done better by Michael Sherwin, CCC, December 07, 2017 » RomiChess
- BBC News; 'Google's ... DeepMind AI claims chess crown' by pennine22, Hiarcs Forum, December 07, 2017
- Press Release Stockfish vs. AlphaZero by Michael Whiteley, FishCooking, December 08, 2017
- AlphaZero reinvents mobility and romanticism by Chris Whittington, Rybka Forum, December 08, 2017 » Alpha Zero's "Immortal Zugzwang Game"
- Reactions about AlphaZero from top GMs... by Norman Schmidt, CCC, December 08, 2017 » Reactions From Top GMs, Stockfish Author
- AlphaZero is not like other chess programs by Dann Corbit, CCC, December 08, 2017
  Re: AlphaZero is not like other chess programs by Rein Halbersma, CCC, December 09, 2017
- Photo of Google Cloud TPU cluster by Norman Schmidt, CCC, December 09, 2017
- Cerebellum analysis of the AlphaZero - Stockfish Games by Thomas Zipproth, CCC, December 11, 2017 » Cerebellum
- Open letter to Google DeepMind by Michael Stembera, FishCooking, December 12, 2017
- recent article on alphazero ... 12/11/2017 ... by Dan Ellwein, CCC, December 14, 2017
- An AlphaZero inspired project by Truls Edvard Stokke, CCC, December 14, 2017
- AlphaZero - Tactical Abilities by David Rasmussen, CCC, December 16, 2017
- In chess,AlphaZero outperformed Stockfish after just 4 hours by Ed Schroder, CCC, December 18, 2017
- AlphaZero - Youtube Videos by Christoph Fieberg, CSS Forum, December 18, 2017
- AlphaZero Chess is not that strong ... by Vincent Lejeune, CCC, December 19, 2017
- David Silver (Deepmind) inaccuracies by Ed Schroder, CCC, December 21, 2017
- AZ vs SF - game 99 by Rebel, Rybka Forum, December 23, 2017
- AlphaZero performance by Martin Sedlak, CCC, December 25, 2017
- A Simple Alpha(Go) Zero Tutorial by Oliver Roese, CCC, December 30, 2017
- AlphaZero: The 10 Top Shots by Walter Eigenmann, CCC, December 30, 2017

2018

- SF was more seriously handicapped than I thought by Kai Laskos, CCC, January 02, 2018
- Chess World to Google Deep Mind..Prove You beat Stockfish 8! by AA Ross, CCC, January 11, 2018
- Article:"How Alpha Zero Sees/Wins" by AA Ross, CCC, January 17, 2018 » How AlphaZero Wins
- Connect 4 AlphaZero implemented using Python... by Steve Maughan, CCC, January 29, 2018 » Connect Four, Python
- Seeing Alphazero in perspective ... by Dan Ellwein, CCC, February 10, 2018

External Links

- AlphaZero from Wikipedia
- AlphaGo Zero - AlphaZero from Wikipedia
- Keynote David Silver NIPS 2017 Deep Reinforcement Learning Symposium AlphaZero,

December 06, 2017, YouTube Video [14]

- A Simple Alpha(Go) Zero Tutorial by Surag Nair, Stanford University, December 29, 2017 [15]
  GitHub - suragnair/alpha-zero-general: A clean and simple implementation of a self-play learning algorithm based on AlphaGo Zero (any game, any framework!)

Reports

- DeepMind's AI became a superhuman chess player in a few hours, just for fun by James Vincent, The Verge, December 06, 2017
- Entire human chess knowledge learned and surpassed by DeepMind's AlphaZero in four hours by Sarah Knapton, and Leon Watson, The Telegraph, December 06, 2017
- Google's 'superhuman' DeepMind AI claims chess crown, BBC News, December 06, 2017 [16]
- DeepMind's AlphaZero crushes chess by Colin McGourty, Chess24.com, December 06, 2017
- One Small Step for Computers, One Giant Leap for Mankind by Dana Mackenzie, Dana Blogs Chess, December 06, 2017
- Google's AlphaZero Destroys Stockfish In 100-Game Match by Mike Klein, Chess.com, December 06, 2017
- The future is here – AlphaZero learns chess by Albert Silver, ChessBase News, December 06, 2017
- AlphaZero: Reactions From Top GMs, Stockfish Author by Peter Doggers, Chess.com, December 08, 2017 » Stockfish, Tord Romstad [17]
- Is AlphaZero really a scientific breakthrough in AI? by Jose Camacho Collados, Medium, December 11, 2017 [18]
- Alpha Zero: Comparing "Orangutans and Apples" by André Schulz, ChessBase News, December 13, 2017
- Kasparov on Deep Learning in chess by Frederic Friedel, ChessBase News, December 13, 2017

Stockfish Match

- AlphaZero vs Stockfish Games • lichess.org
- The chess games of AlphaZero (Computer) from chessgames.com
- Cerebellum AlphaZero Analysis » Cerebellum [19]
- Deep Mind Alpha Zero's "Immortal Zugzwang Game" against Stockfish by Antonio Radic, December 07, 2017, YouTube Video [20] [21] » Zugzwang

- Deep Mind AI Alpha Zero Dismantles Stockfish's French Defense by Antonio Radic, December 08, 2017, YouTube Video
- How AlphaZero Wins by Dana Mackenzie, Dana Blogs Chess, December 15, 2017 [22]

Misc

- How to build your own AlphaZero AI using Python and Keras by David Foster, January 26, 2018 » Connect Four, Python [23]
- Can - Halleluwah, from Tago Mago 1971, YouTube Video

lineup: Irmin Schmidt, Michael Karoli, Holger Czukay, Damo Suzuki, Jaki Liebezeit

References

1. ^ David Silver, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, Demis Hassabis (**2017**). *Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm*. arXiv:1712.01815
2. ^ Alpha Zero by BB+, OpenChess Forum, December 06, 2017
3. ^ Krampus at Perchtenlauf in Klagenfurt, Image by Anita Martinz, December 02, 2006, CC BY 2.0 , Wikimedia Commons
4. ^ "5th of December - The Krampus has come" was suggested by Michael Scheidl in AlphaZero by Peter Martan, CSS Forum, December 06, 2017, with further comments by Ingo Althöfer
5. ^ AlphaGo Zero: Learning from scratch by Demis Hassabis and David Silver, DeepMind, October 18, 2017
6. ^ The principle of residual nets is to add the input of the layer to the output of each layer. With this simple modification training is faster and enables deeper networks, see Tristan Cazenave (**2017**). Residual Networks for Computer Go. IEEE Transactions on Computational Intelligence and AI in Games, Vol. PP, No. 99, pdf
7. ^ Residual Networks for Computer Go by Brahim Hamadicharef, CCC, December 07, 2017
8. ^ Re: AlphaZero is not like other chess programs by Rein Halbersma, CCC, December 09, 2017
9. ^ First In-Depth Look at Google's TPU Architecture by Nicole Hemsoth, The Next Platform, April 05, 2017
10. ^ Photo of Google Cloud TPU cluster by Norman Schmidt, CCC, December 09, 2017
11. ^ First In-Depth Look at Google's New Second-Generation TPU by Nicole Hemsoth, The Next Platform, May 17, 2017
12. ^ Under The Hood Of Google's TPU2 Machine Learning Clusters by Paul Teich, The Next Platform, May 22, 2017
13. ^ David Silver, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, Demis Hassabis (**2017**). *Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm*. arXiv:1712.01815
14. ^ AlphaZero explained by one creator by Mario Carbonell Martinez, CCC, December 19, 2017
15. ^ A Simple Alpha(Go) Zero Tutorial by Oliver Roese, CCC, December 30, 2017
16. ^ BBC News; 'Google's ... DeepMind AI claims chess crown' by pennine22, Hiarcs Forum, December 07, 2017
17. ^ Reactions about AlphaZero from top GMs... by Norman Schmidt, CCC, December 08, 2017
18. ^ recent article on alphazero ... 12/11/2017 ... by Dan Ellwein, CCC, December 14, 2017
19. ^ Cerebellum analysis of the AlphaZero - Stockfish Games by Thomas Zipproth, CCC, December 11, 2017
20. ^ AlphaZero reinvents mobility and romanticism by Chris Whittington, Rybka Forum, December 08, 2017
21. ^ Immortal Zugzwang Game from Wikipedia
22. ^ Article:"How Alpha Zero Sees/Wins" by AA Ross, CCC, January 17, 2018

23. ^ Connect 4 AlphaZero implemented using Python... by Steve Maughan, CCC, January 29, 2018

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