ICGA Journal 39 (2017) 222–227
DOI 10.3233/ICG-170030
IOS Press

Hex 2017: MoHex wins the 11x11 and 13x13 tournaments

Ryan Hayward * and Noah Weninger
Department of Computer Science, University of Alberta, Canada

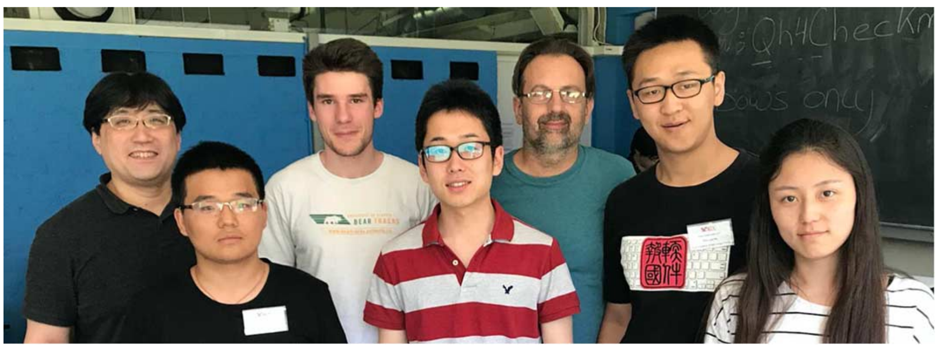

Fig. 1. Participants at the Hex competitions. From left, Masahito Yamamoto, You RunZe, Noah Weninger, Kei Takada, Ryan Hayward, Ma Shengjie and Wu Tong.

1. THE TOURNAMENTS

There were two Hex tournaments at the 2017 Olympiad: board size 11x11 and board size 13x13. Three programs competed in each tournament. These are at present the only annual computer Hex tournaments. 11x11 is the original board size introduced by Piet Hein in 1942. Recently, all 1-move openings on 9x9 Hex have been solved by computers, as have two 10x10 openings (Pawlewicz and Hayward, 2013). So, in recent years the 13x13 competition, a preferred size in the Little Golem online Hex community (Malaschitz, 2009), was introduced.

The 11x11 contestants were HEXCITED by Ma Shengjie from China, EZO-CNN by Kei Takada, supervised by Masahito Yamamoto from Japan, and MOHEX by Broderick Arneson, Ryan Hayward, Philip Henderson, Aja Huang, Jakub Pawlewicz, Noah Weninger, and Kenny Young from Canada. The 13x13 contestants were HEXCELLENT by Wu Tong from China, EZO-CNN, operated by You RunZe and (another, no relation) Wu Tong from China, and MOHEX-CNN by Chao Gao and the MOHEX authors from Canada.

MOHEX (Huang et al., 2014), the winner of the previous seven Olympiad Hex competitions (Hayward et al., 2013), is an MCTS program that uses the Benzene Hex framework built on the code base of FUEGO (Enzenberger et al., 2007–2012). MOHEX performs knowledge computation in UCT tree nodes visited at least 256 times. MOHEX ran on Firecreek, a 24-core shared-memory machine, with

*Corresponding author. E-mail: hayward@ualberta.ca.

four cores reserved for the DFPNS solver (Pawlewicz and Hayward, 2013) which produces perfect play if it solves the position within the time allotted. MOHEX uses a book built by Broderick Arneson with Thomas Lincke's method (Lincke, 2000). Noah Weninger expanded the book and added a feature allowing the use of rotational symmetry for openings whose rotation is in the book. For each board size, the book covers at least eight openings.

MOHEX-CNN is a convolutional neural net (CNN) version of MOHEX. At each new node of the Monte Carlo search tree, a policy CNN biases child selection by initializing child visit and win counts with artificial values. MOHEX-CNN ran remotely on a machine with two CPUs and one GPU.

EZO-CNN is a CNN version of EZO, which competed in the 2016 and previous Olympiads. EZO, based on the Benzene framework, uses iterative deepening alpha-beta search with an evaluation function using a linear combination of two network connectivity measures (Takada et al., 2015). EZO-CNN uses a convolutional neural policy network for move ordering. EZO-CNN ran remotely on a machine with two CPUs and one GPU, with one CPU-thread for search and one CPU-thread for Benzene's Depth-First Proof Number Search endgame solver.

HEXCITED and HEXCELLENT are new MCTS programs written respectively by Ma Shengjie and Wu Tong of the Beijing Institute of Technology. Each ran locally on a laptop.

Each match between two competitors was eight games with 30′/game per player. The tournaments started on July 1st and finished on July 5th. See Tables 1 and 2 and Figures 2 through 7. In many games, the losing operator resigned soon after Benzene solved the game. Figures 4 and 7 show some typical continuations after resignations.

Table 1
The results of the 11x11 tournament

id	11 × 11	MOHEX	EZO-CNN	HEXCITED	Total	Result
M	MOHEX		7-5	4-0	11-5	Gold
E	EZO-CNN	5-7		3-0	8-7	Silver
H	HEXCITED	0-4	0-3		0-7	Bronze

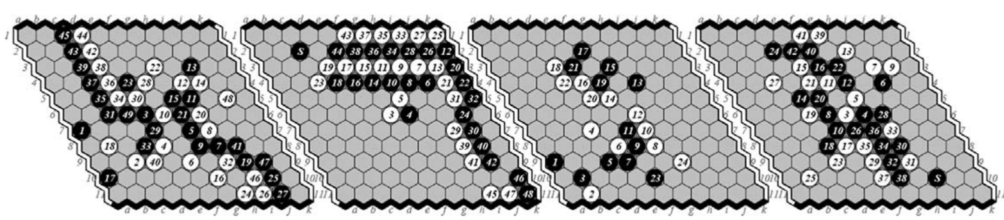

Fig. 2. HEXCITED – MOHEX 11x11 games 1-4: M–H 1-0, H–M 0-1, M–H 1-0 and H–M 0-1.

The 11x11 tournament.[1] In a game, if the second move is 'swap', players exchange colors and the first player plays the next move: in the corresponding diagram, the black 'S' marks the first two moves and the white '3' the next move. In the figure titles, 'A-B 1-0' indicates that A plays first, starting as Black, and A wins, as White if B swapped and as Black if not.

The new program HEXCITED opened strongly in several games. For example, in its first game against MOHEX, HEXCITED is in a strong position after 15 moves, but misses the promising **16. W[g3]**.

[1] Hayward and Weninger (2017) gives .sgf game records and other source files for this report. Arneson (2014) provides an .sgf viewer. The Smart Game Format (sgf) was developed by (Kierulf et al., 1987).

Even with this move, HEXCITED would be hard pressed to beat MOHEX which uses, like EZO-CNN, a Benzene framework including a virtual-connection engine. This often finds a win before a typical tree search detects that the game is decided. HEXCITED was unable to win against either opponent. For this reason, once the final ranking was decided, HEXCITED's operator resigned its remaining games.

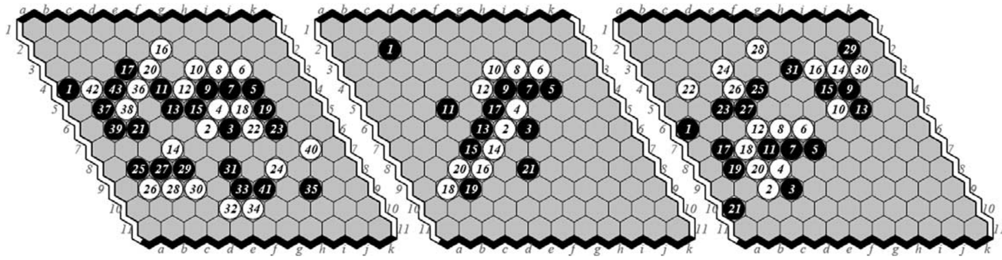

Fig. 3. HEXCITED – EZO-CNN 11x11 games 1-3: E–H 1-0 (Black finishing **e8** or **h7**), H–E 0-1 and E–H 1-0.

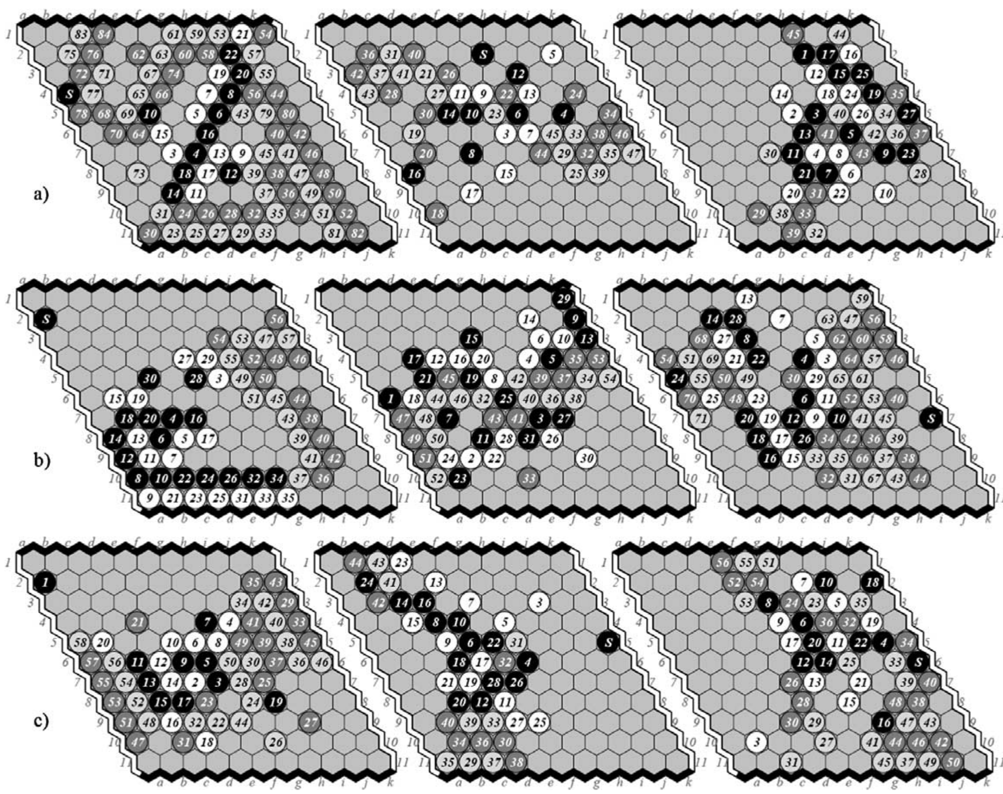

Fig. 4. EZO-CNN – MOHEX 11x11 games (a) 1-3: E–M 0-1, M–E 1-0, E–M 1-0, (b) 4-6: M–E 1-0, M–E 0-1, E–M 1-0, and (c) 7-9: M–E 0-1, E–M 0-1, (play-off) E–M 0-1. The dark (light) grey stones for Black (White) show typical continuations after resignations.

Due to the late arrival of HEXCITED, MOHEX and EZO-CNN in fact played their opening eight games first. The contest for gold later required a playoff between them, see Figs 4(c) and 5, which was not decided until the very last of the initial four games scheduled.

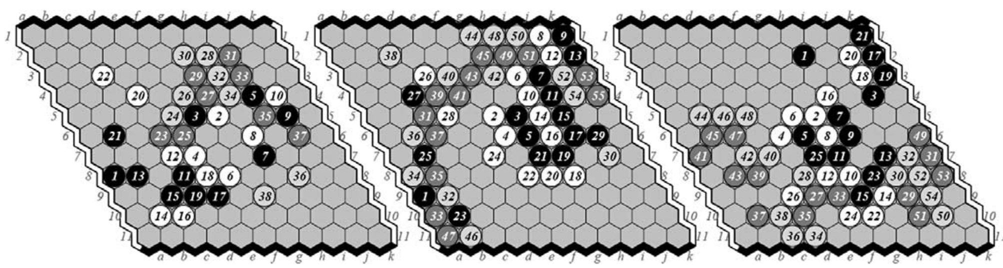

Fig. 5. EZO-CNN – MOHEX 11x11 games 10-12 in the play-off: M–E 0-1, M–E 1-0 and E–M 0-1.

The 13x13 tournament. For this tournament, no playoff was required. Again, the final ranking was determined before all scheduled games had been played, so the operator of HEXCELLENT resigned its final games without play.

Table 2

The results of the 13x13 tournament

id	13 × 13	MOHEX-CNN	EZO-CNN	HEXCELLENT	Total	Result
M	MOHEX-CNN		6-2	2-0	8-2	Gold
E	EZO-CNN	2-6		4-0	6-6	Silver
H	HEXCELLENT	0-2	0-4		0-6	Bronze

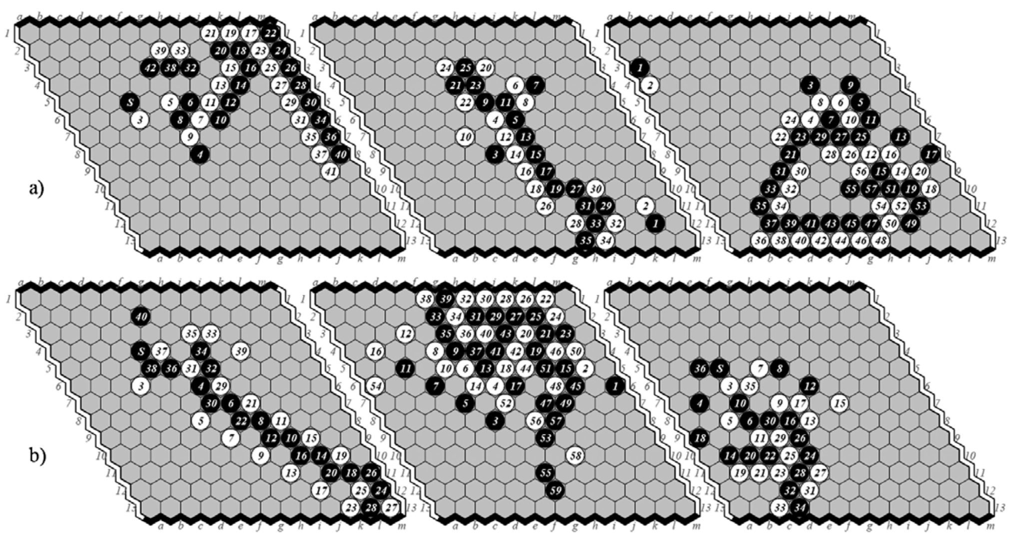

Fig. 6. HEXCELLENT 13x13 games (a) 1-3: H–M 0-1, M–H 1-0, E–H 1-0, and (b) 4-6: H–E 0-1, E–H 1-0, H–E 0-1.

2. CONCLUSIONS

On 11x11, MOHEX and EZO-CNN seem evenly matched. MOHEX's search seems too narrow, especially near the opening. In positions with plural good-looking moves, initial playouts can bias final move selection and MOHEX sometimes makes a bad move early in the game. The purpose of

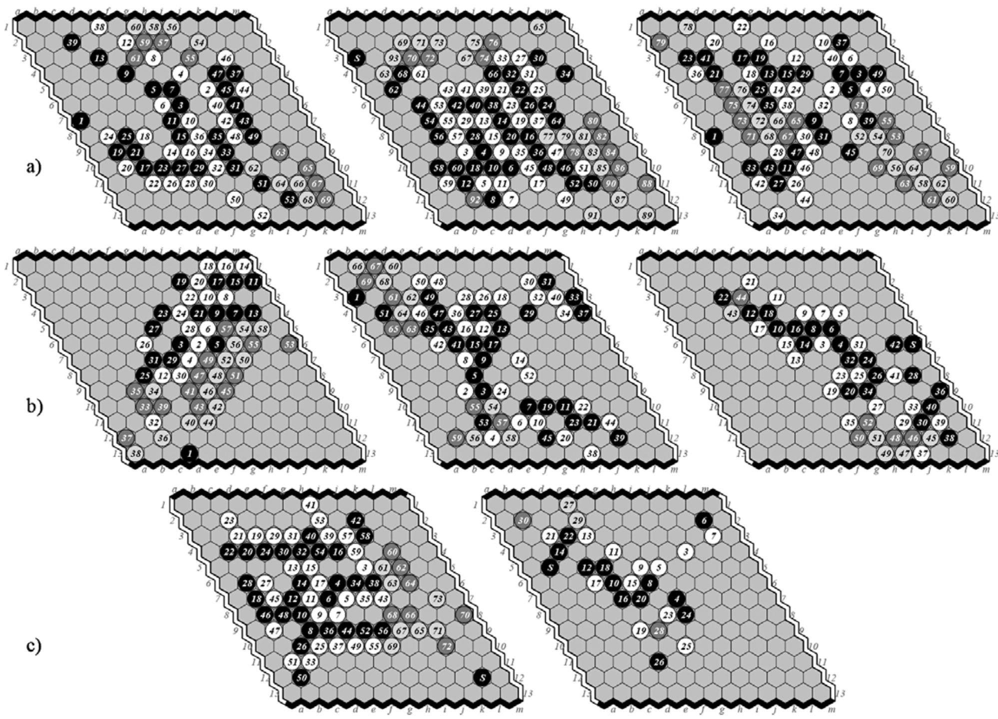

Fig. 7. Ezo-CNN – MoHex-CNN 13x13 games (a) 1-3: M–E 1-0, E–M 1-0 and M–E 0-1, (b) 4-6: E–M 0-1, M–E 1-0 and E–M 0-1 and (c) 7-8: M–E 1-0 and E–M 0-1.

MoHex's book is to avoid early bad moves. This played a role in the final playoff game where Ezo-CNN opened with **1. B[h2]**.

In an earlier game, Ezo-CNN played the same opening and won easily after MoHex replied **2. W[f5]** which is not on the main diagonal and does little to block Black. But in the playoff game, MoHex replied **2. W[g5]** and won. Post-tournament testing shows that MoHex likes both moves more than all others but that the superiority of **g5** to **f5** is not clear. If initial rollouts are unlucky, MoHex will not see that **g5** is better.

On 13x13, MoHex-CNN seems stronger than Ezo-CNN. MoHex-CNN suffered from a lack of testing prior to the tournament. Consequently, it played the first three games with its rapid access value estimation (RAVE) feature turned off. This search was too narrow so RAVE was turned on for the remaining games which improved performance considerably.

ACKNOWLEDGEMENTS

We thank the NSERC Discovery Grant Program for research funding, Martin Müller for the loan of his machine Firecreek and an anonymous referee for detailed feedback.

REFERENCES

Arneson, B. (2014). HexGui: an sgf Hex viewer, https://github.com/ryanbhayward/hexgui.

Enzenberger, M., Müller, M., Arneson, B., Segal, R., Xie, F. & Huang, A. (2007–2012). FUEGO: a set of C++ libraries at http://fuego.sourceforge.net/.

Hayward, R.B., Arneson, B., Huang, S.-C. & Pawlewicz, J. (2013). MoHex wins Hex tournament. *ICGA J.*, *36*(3), 180–183. doi:10.3233/ICG-2013-36318.

Hayward, R.B. & Weninger, N. (2017). https://github.com/ryanbhayward/icga-olympiad-hex. Source files for this report.

Huang, S.-C., Arneson, B., Hayward, R.B., Müller, M. & Pawlewicz, J. (2014). MoHex 2.0: A pattern-based MCTS Hex player. In H.J. van den Herik, H. Iida and A. Plaat (Eds.), *Computers and Games* LNCS (Vol. 8427, pp. 60–71). Springer. Revised selected papers from CG2013, The 8th International Conference, Yokohama, Japan, August 13–15, 2013. ISBN 978-3-319-09164-8.

Kierulf, A., Müller, M. & Hollosi, A. (1987). https://en.wikipedia.org/wiki/Smart_Game_Format. Smart game format.

Lincke, T.R. (2000). Strategies for the automatic construction of opening books. In T.A. Marsland and I. Frank (Eds.), *Computers and Games*, LNCS (Vol. 2063, pp. 74–86). Springer. Revised papers from CG2000, the 2nd International Conference, Hamamatsu, Japan. ISBN 3-540-43080-6.

Malaschitz, R. (2009). http://senseis.xmp.net/?LittleGolem. Little Golem: an online turn-based boardgame server.

Pawlewicz, J. & Hayward, R.B. (2013). Scalable parallel DFPN search. In H.J. van den Herik et al. (Eds.), *Computers and Games – 8th International Conference, CG 2013*, Yokohama, Japan, August 13–15, 2013, Revised Selected Papers (pp. 138–150).

Takada, K., Honjo, M., Iizuka, H. & Yamamoto, M. (2015). Developing computer Hex using global and local evaluation based on board network characteristics. In A. Plaat, H.J. van den Herik and W.A. Kosters (Eds.), *Advances in Computer Games*. LNCS (Vol. 9525, pp. 235–246). Springer. Revised selected papers from ACG2015, the 14th International Conference, Leiden, the Netherlands, July 1–3, 2015. doi:10.1007/978-3-319-27992-3_21.