HEXY WINS HEX TOURNAMENT

Vadim Anshelevich[1]

Richardson, Texas

Results

Three programs competed in the Hex tournament during the 5th Computer Olympiad (London, Alexandra Palace) on August 24-25, 2000.

- HEXY by Vadim Anshelevich, Vanshel Consulting, Texas
- QUEENBEE by Jack van Rijswijck, University of Alberta, Canada
- KILLERBEE by Emanuele Brasa, MicroRing, Italy

To the best of my knowledge it was the first Computer Hex tournament ever held. The final standings are given in Table 1.

Program	Author	Score	Rank
HEXY	Vadim Anshelevich	8	1
QUEENBEE	Jack van Rijswijck	4	2
KILLERBEE	Emanuele Brasa	0	3

Table 1: Final standings of the Hex tournament.

The Game of Hex

Hex is a two-player game played on a rhombic board with hexagonal cells (see Figure 1) The classic board is 11×11, but it can be any size. The 10×10 and 14×14 board sizes are also popular. The players, Black and White, take turns putting pieces of their colour on empty cells of the board. Black's objective is to connect the two opposite black sides of the board with a chain of black pieces. White's objective is to connect the two opposite white sides of the board with a chain of white pieces. In practice, players often employ the swap rule, i.e., the second player has the option of taking the first player's opening move.

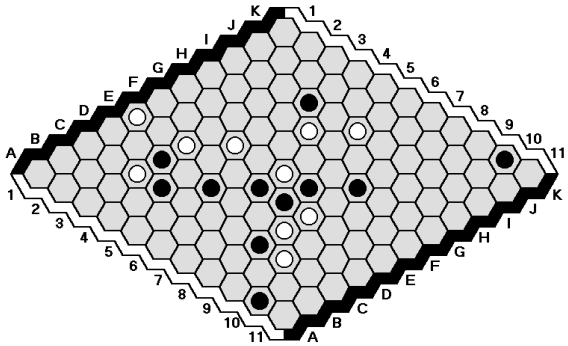

Figure 1

Hex was invented by a Danish poet and mathematician Piet Hein in 1942 at the Niels Bohr Institute for Theoretical Physics, and became popular under the name of Polygon. It was re-discovered in 1948 by future Nobel Prize laureate John Nash, when he was a graduate student at Princeton. Parker Brothers marketed a version of the game in 1952 under the name Hex. The game was presented to the general public in *Scientific American* by Martin Gardner in 1959.

The game of Hex can never end in a draw. This follows from the fact that if all cells of the board are occupied then a winning chain for Black or White must necessarily exist. John Nash showed that a winning strategy exists for the first player. However, this is only a proof of existence, and the winning strategy is not known for boards larger than 7×7.

[1] Vanshel Consulting, 1200 Navaho Trail, Richardson, Texas 75080, USA. Email: vanshel@earthlink.net.

Participants

The winner program, HEXY, spends most of computing resources on deep analysis of a relatively small number of Hex positions, and does not perform massive game-tree search. HEXY exploits an original approach, which allows to reduce the evaluation of Hex positions to an analysis of a hierarchy of simpler sub-positions. The paper (Anshelevich, 2000), where this approach was proposed, has been selected as an Outstanding Paper of AAAI-2000 National Conference. Windows version of the program is publicly available at the website: http://home.earthlink.net/~vanshel.

The second program, QUEENBEE, exploits a more traditional technique of massive game-tree search, with a computationally inexpensive evaluation function. QUEENBEE uses an iterative-deepening alpha-beta search enhanced with Minimal Window/Principal Variation Search and transposition tables. QUEENBEE's search incorporates the fractional ply searching ideas of the "Sex Search algorithm" (Van Rijswijck, 2000).

Emanuele Brasa's program, KILLERBEE, exploits a geometrically oriented evaluation function. The program divides the connectivity problem for full-board positions into the ones for local positions. Then KILLERBEE uses a small database of elementary connectivity patterns. No published description of the program is available.

Sadly, only three programs participated in the tournament. I believe that the single most important reason for the low participation is the lack of interest in Hex research in academia. The only exception is the University of Alberta GAMES group, where QUEENBEE was developed. My personal communications with potential participants revealed two additional reasons. The first reason was the uncertainty regarding whether this Computer Olympiad would take place at all. Not too much time was left for preparations after it had been announced that the Olympiad would really take place. The second more psychological reason was that for almost a year prior to the Olympiad, there had existed the obvious leader, HEXY, a strong program available to everybody for playing. Some of the potential participants privately admitted that it would be a difficult decision to invest significant amount of effort and money with the clear understanding that their program had little chances to be the first.

I hope that the simplicity of rules and unique beauty of this game as well as the latest development in Hex research, will create new interest in Hex, both in academia and in general public.

Tournament Rules and Protocol

The brief description of the rules and the protocol of this tournament follow below:

1. The board size is 11×11.
2. The opening program makes the first move as Black.
3. The responding program has the right to swap. If responding program decides to swap, then the opening program makes the second move as White. Otherwise, the responding program makes the second move as White. This rule means that the Black and the White roles are assigned to playing programs only after the decision regarding to the swap has been made.
4. Each program must complete its moves for one game in 30 minutes.
5. The tournament was two rounds all-play-all.
6. Each round consisted of two games - opening and responding for each program.
7. In the second round, the operator of the opening program might select the opening move manually.
8. The operator of the program had the right to resign on behalf of his program.

By mutual agreement, games between HEXY and KILLERBEE were played using a Playsite version of the swap rule. In this case the responding player removes the opening black stone from the board and put the white stone in the mirror position. Then the opening program continues to play as Black.

Analysis of Games

Emanuele Brasa's program, KILLERBEE, was originally designed for playing on small boards. The author did not have sufficient time to adapt this program for 11×11 board. In many positions the program was not able to produce reasonable candidates for a move. KILLERBEE lost all official games to the opponents in

earlier stages of the games. However, in unofficial games on a smaller board (7×7) KILLERBEE demonstrated a very strong play.

The 1st game of the first round, between HEXY and QUEENBEE started with QUEENBEE's move 1. B2. HEXY swapped and QUEENBEE continued 2. F6. The first non-standard HEXY's move 9. I5 (see Figure 2) created a short-term weakness for Black at H5. However, this move significantly weakened the White's outpost at I3, and generally created a Black dominance on the East. (I personally would never play this move.)

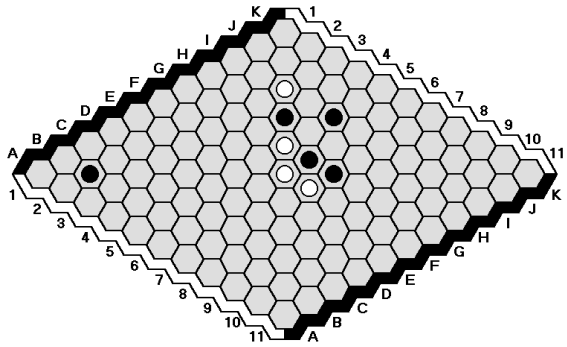

Figure 2

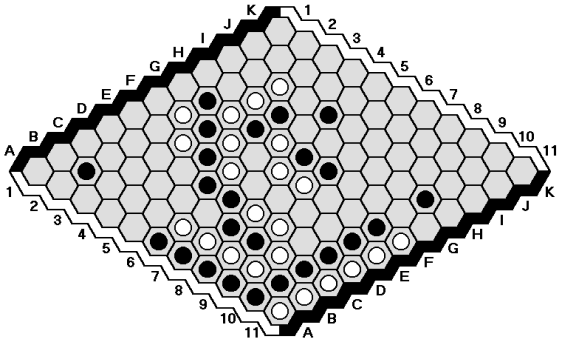

Figure 3

The future development of this game shows that White was not able to use Black's weakness at H5, but Black later fully used its dominance on the East. White allowed Black to build a ladder on the South-East, easily connectable to the North-West black border. Finally, the move 47. H10 connected the black ladder with the South-East black border using Black's dominance in the area (see Figure 3).

In the return game of the first round HEXY started with 1. A2. QUEENBEE swapped and HEXY continued 2. F6. Black's move 15. K2 (see Figure 4) was a very serious and I believe the critical mistake. This move allowed White to connect to the South-West white border at 16. C4, with the perspectives of a strong attack in two directions through H4-I3 and E5-F6. Black was left with nothing else, but passive defense along the North-East border. According to my analysis, by the time when Black made their fatal move 37. K8, the fate of the game was already determined.

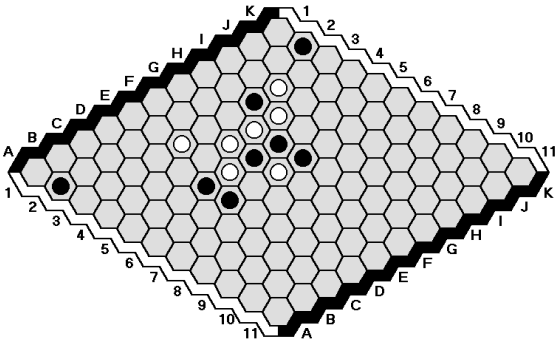

Figure 4

According to the tournament rules, the opening move in the 1st game of the second round was selected by QUEENBEE's operator. It was 1. A2. HEXY responded 2. F6. As a result, the position from the previous game appeared on the board. During the next fourteen moves both programs followed the previous game until QUEENBEE's operator decided to resign.

The last game was resigned by J. van Rijswijck on behalf of QUEENBEE without playing.

References

Anshelevich, V. V. (2000). The Game of Hex: An Automatic Theorem Proving Approach to Game Programming. In *Proceedings of the Seventeenth National Conference on Artificial Intelligence*, pp. 189-194. Menlo Park, Calif.: AAAI Press.

Van Rijswijck, J. (2000). Are Bees better than Fruitflies? (Experiments with a Hex playing program). *AI'00: Advances in Artificial Intelligence, 13th biennial Canadian Society for Computational Studies of Intelligence (CSCSI) Conferenc*e, (ed. H. Hamilton), pp. 13-25, Springer-Verlag, New York, NY.

Games
The games played between QUEENBEE and KILLERBEE are not available to the author of this report.

HEXY vs. KILLERBEE 08/24/2000 (The 1st game of the first round)
1.A2 2.F6 3.G6 4.G5 5.J3 6.E7 7.I5 8.C8 9.F8 White (KILLERBEE) resigned

KILLERBEE vs. HEXY 08/24/2000 (The 2nd game of the first round)
1.B2 SWAP TO B2 2.F6 3.F7 4.G5 5.H6 6.E7 7.E8 8.F5 9.C9 Black (KILLERBEE) resigned

HEXY vs. KILLERBEE 08/24/2000 (The 1st game of the second round)
1.B1 2.F6 3.G6 4.G5 5.I4 6.E7 7.J2 8.H5 9.I5 10.F5 11.H7 12.I3 13.J3 White (KILLERBEE) resigned

KillerBee vs. Hexy 08/24/2000 (The 2nd game of the second round)
1.E1 SWAP TO A5 2.F6 3.F7 4.G5 5.D8 6.E7 7.E9 8.F5 9.H6 10.G7 11.G6 12.E8 13.D9 14.F8 15.F9 16.H7 17.H8 18.I7 19.I8 Black (KILLERBEE) resigned

QUEENBEE vs. HEXY 08/24/2000 (The 1st game of the first round)
1.B2 SWAP 2.F6 3.G6 4.F7 5.G7 6.I3 7.H4 8.G5 9.I5 10.H3 11.G4 12.G3 13.E4 14.E3 15.F3 16.F2 17.G2 18.F4 19.D6 20.E5 21.D5 22.D8 23.C8 24.D7 25.C7 26.C9 27.A10 28.A11 29.B10 30.B11 31.C10 32.B9 33.A9 34.C11 35.D10 36.D11 37.E10 38.E11 39.F10 40.B8 41.A8 42.B7 43.A7 44.B6 45.A6 46.F11 47.H10 48.G10 49.H8 50.G9 51.F8 52.B5 53.A5 54.B3 55.B4 56.C4 57.C3 58.C2 59.E2 60.D2 61.D3 62.H9 63.J8 64.I8 65.J7 66.I9 67.J9 68.I7 69.J6 White (QUEENBEE) resigned

HEXY vs. QUEENBEE 08/25/2000 (The 2nd game of the first round)
1.A2 SWAP 2.F6 3.G6 4.I3 5.H3 6.H4 7.G5 8.G4 9.F5 10.F4 11.D5 12.E5 13.D6 14.E3 15.K2 16.C4 17.J4 18.I5 19.J5 20.K1 21.J2 22.I6 23.J6 24.I7 25.J7 26.I8 27.J8 28.I10 29.I9 30.H10 31.H9 32.G10 33.K9 34.J11 35.G8 36.F9 37.K8 38.E8 39.B9 40.D8 41.D7 42.F8 43.D9 44.K10 45.G9 46.F10 47.E6 48.G7 Black (QUEENBEE) resigned

QUEENBEE vs. HEXY 08/25/2000 (The 1st game of the second round)
1.A2 2.F6 3.G6 4.I3 5.H3 6.H4 7.G5 8.G4 9.F5 10.F4 11.D5 12.E5 13.D6 14.E3 White (QUEENBEE) resigned

HEXY vs. QUEENBEE 08/25/2000 (The 2nd game of the second round)
QUEENBEE resigned without playing