nexC

Project Overview

nexC is a command-line interface for the game of Nex. This engine provides support for running Nex games amongst players upon a two-way communication link over a network. nexC also includes a Nex visualization tool, called nexViz. This tool can be used to visualize Nex games, either through a text file or a direct input of moves into the webpage.

Game description

Nex is a connection game played between two players, namely Black and White. This game is a variation of the game of Hex. Fig.0 presents the board upon which this game is played, produced by nexC:

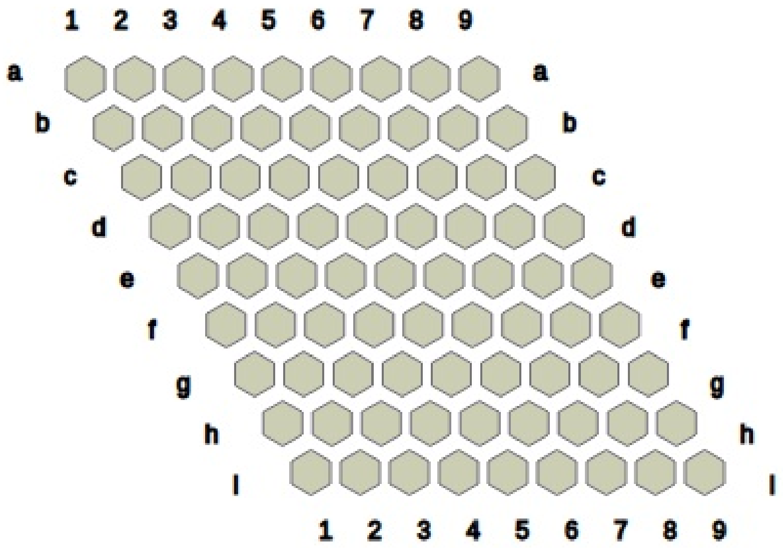


Fig.0: Initial configuration of the 9 x 9 Nex board.

The game is played by placing stones on the board, turn by turn. By convention, Black plays the first move. There are three kinds of stones: Black (**B**), White (**W**) and Neutral (**?**). Given a state of the game and the player to move, the player may either play a *Generate* move or a *Transform* move.

1. Generate move: The player places a stone of their colour and a Neutral stone into two distinct empty cells.

   For example,

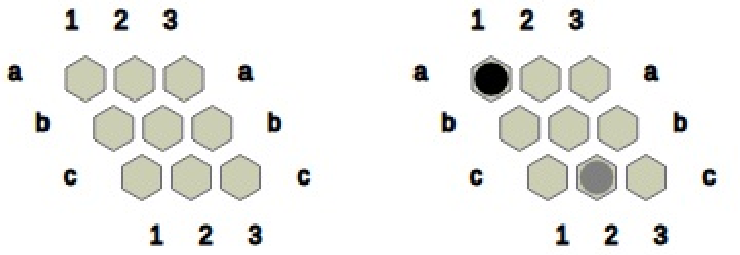


Fig.1 shows the state obtained after Black plays the move Ba1?c2 on the starting position of 3 x 3 Nex, Black places a * B** on *a1* and a **?** on *c2*.*

1. Transform move: The player converts two Neutral stones on the board into their colour and convert one of their coloured stones into a Neutral stone.

   For example,

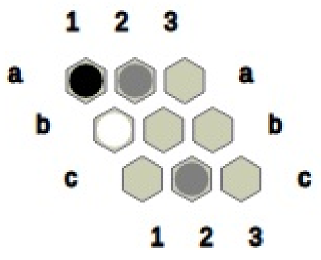


Fig.3: A game position in 3 x 3 Nex

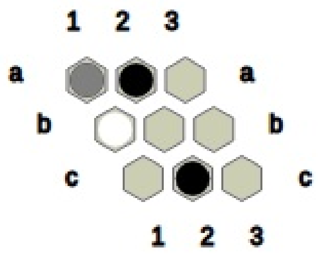


Fig.4: The state obtained after Black plays the move Ba2Bc2?a1, where Black converts * ?** at *a2* and *c2* to **B** and **B** at *a1* to **?**.*

Terminology

A cell is *empty* if it contains no stone.

We say that two cells are connected if both cells are nonempty and both cells contain stones of the same kind.

We define a connection between two cells, A and B, a nonempty sequence of cells such that every consecutive pair of cells in the sequence are connected, with A and B being the first and last cells in the sequence. A connection is a *B-connection* if every cell in the connection is occupied by a **B** stone. Similarly, a connection is a *W-connection* if every cell in the connection is occupied by a **W** stone.

The *objective* for Black is to form a B-connection between some cell in row *a* and a cell in the bottommost row. Likewise, the *objective* for White is to form a W-connection between some cell in column *1* and some cell in the rightmost column. If neither objective is satisfied and there is no legal move that can be played by the player to move, then we conclude that the game has terminated in a *draw*.

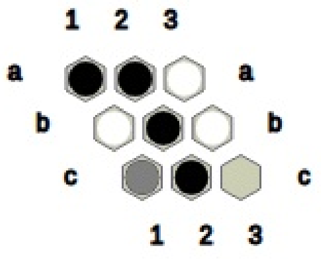


Fig.5: Black wins this position with the help of the B-connection (a2, b2, c2).

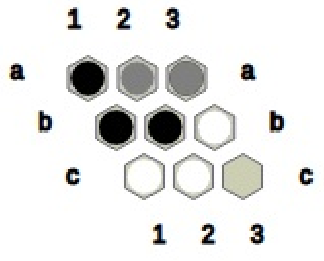


Fig.6: White wins this position with the help of the W-connection (c1, c2, b3).

The game terminates when either player wins or no legal moves exist. Legal moves exist if and only if there are at least two empty cells for the player to play a generate move or at least one Neutral stone to allow a transform move to be playable.

We define an *opening*, or an *opening move*, as the first move played on the initial state of the game. Let S be the initial state of the game. Let A be an opening and S' be the state obtained after playing A on S. We say A is *winning* if for every A' that can be played on S' there exists a sequence of moves that satifies the objective for Black. Such a sequence is defined as a *winning strategy* for Black. We say A is *losing* if there exists a move sequence which satisfies the objective for White. Such a move sequence is defined as the *winning strategy* for White.

Utility

Follow the steps below to run the program: After cloning this repository,

```
cd nexc
mkdir obj
make run
```

Now attach each player by running their executables. For instance, to run Solver 1.0:

```
cd nexm/solver/
make run
```

Communication Protocol

The server and the players are expected to follow the protocol given below; following are the different input commands a player may receive from the server:

1. "rR-cC#"

```
* Server sends the game settings (format may be extended
later). R denotes the number of rows of the board and
C denotes the number of columns.
```

1. "!"
   - Due to an unexpected error caused by a player or the server, the player must exit with status 1.
2. "?"
   - Server expects the player to send a move in the following valid format and type; **"#RC#RC(#RC)"**. An invalid move type or format will cause the server to terminate.
3. "+"
   - Server informs the player that it has won the game. The player must also terminate upon receiving this input.
4. "-"
   - Server informs the player that it has lost the game. The player must also terminate upon receiving this input.
5. "#"
   - Server informs the player that the game ended in a draw. The player must also terminate upon receiving this input.
6. ">(...)" (string with '>' as the first character)
   - The substring followed by '>' is the most recent move that updated the server state. No response is expected.

Issues

- Technical
  - Server to be able to run tournaments (/Makefile)
  - Support for Mac and Windows
  - Report search information
    - number of nodes in the game tree
    - number of nodes pruned
    - number of moves simulated
    - time taken to determine a move at various depths
    - number of leaf nodes

- Theoretical
    - Game tree complexity
- Implementation
    - Improve algorithms implemented in solver 1.0
    - Good heuristic evaluation
        - number of legal moves available from a state
        - minimum number of stones to win
        - board dominance
        - number of chains
        - weak vs strong connections
        - mustplay regions
            - preserving strong connections
            - defensive plays

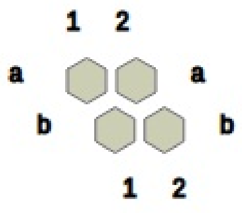
Nex Problems

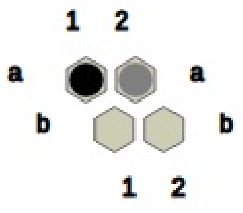
- **3x3 Nex**
    1. Find all winning openings for Black and conclude that a winning strategy exists for the first player.
    2. Find all weak openings for Black and reason why these openings are weak. How can White use these openings to perhaps win the game?
- **NxN Nex**
    1. Describe the game tree.
    2. Where should the Neutral stones be placed?
    3. Find strong and weak openings.
    4. How should the game states be evaluated?
    5. Is Nex a first player win game?

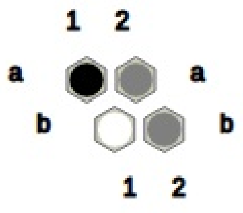
What do we know about Nex so far?

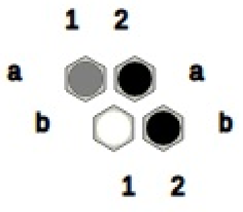
Combinatorics behind 2x2 Nex and 2x2 Hex

- Number of openings: 12 in Nex, 4 in Hex
- The opening **Ba1?a2** is the unique winning opening in 2x2 Nex. Every other opening concludes in a draw.

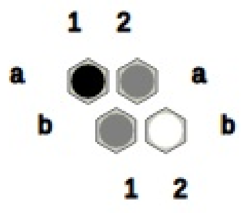


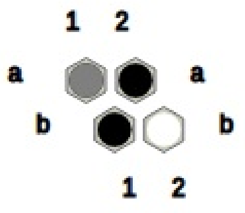






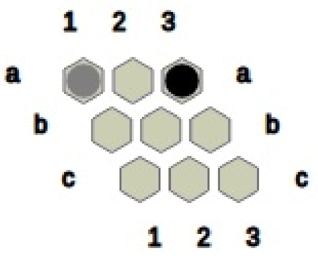
Alternatively, if White responds by **Wb2?b1** to **Ba1?a2**,

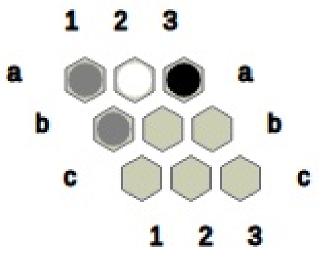


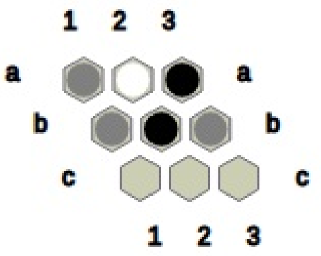


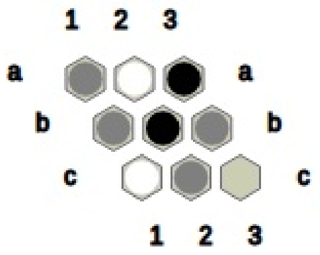
Hence, **Ba1?a2** is indeed a winning opening in 2x2 Nex.

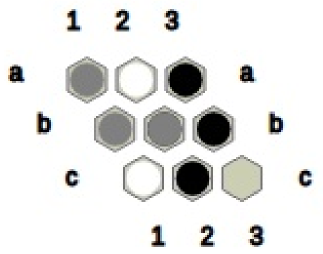
- There are 61 nodes in the game tree of 2x2 Nex, comparing with 65 nodes in the game tree of 2x2 Hex. ##### Solver 1.0 vs Solver 1.0 on 3x3 Nex











Nex players

- Solver 1.0
  - implements Alpha-beta Negamax search
  - state space complexity: O(25mn) bytes
  - intractable for boards bigger than 3x3
  - takes 25s. on average to perform a full game tree search on an empty 3x3 board
- Solver 2.0 (Under testing phase)
  - implements Alpha-beta Negamax search
  - state representation using a bitboard, where each cell is denoted using 2 bits
  - state space complexity: O(10mn) bits
  - intractability?
  - takes 22s. on average to perform a full game tree search on an empty 3x3 board
  - drew against Solver 1.0
  - won 8, drew 2, lost 0; against a pseudorandom player
- Random Bits (Coming soon...)
  - will implement Monte Carlo Tree Search
  - state representation as in Solver 2.0