Evolutionary Game Design

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"Humies" entry

GECCO 2012

Submission

LUDI system for evolving board games

First (and only) fully computer-generated games to be commercially published
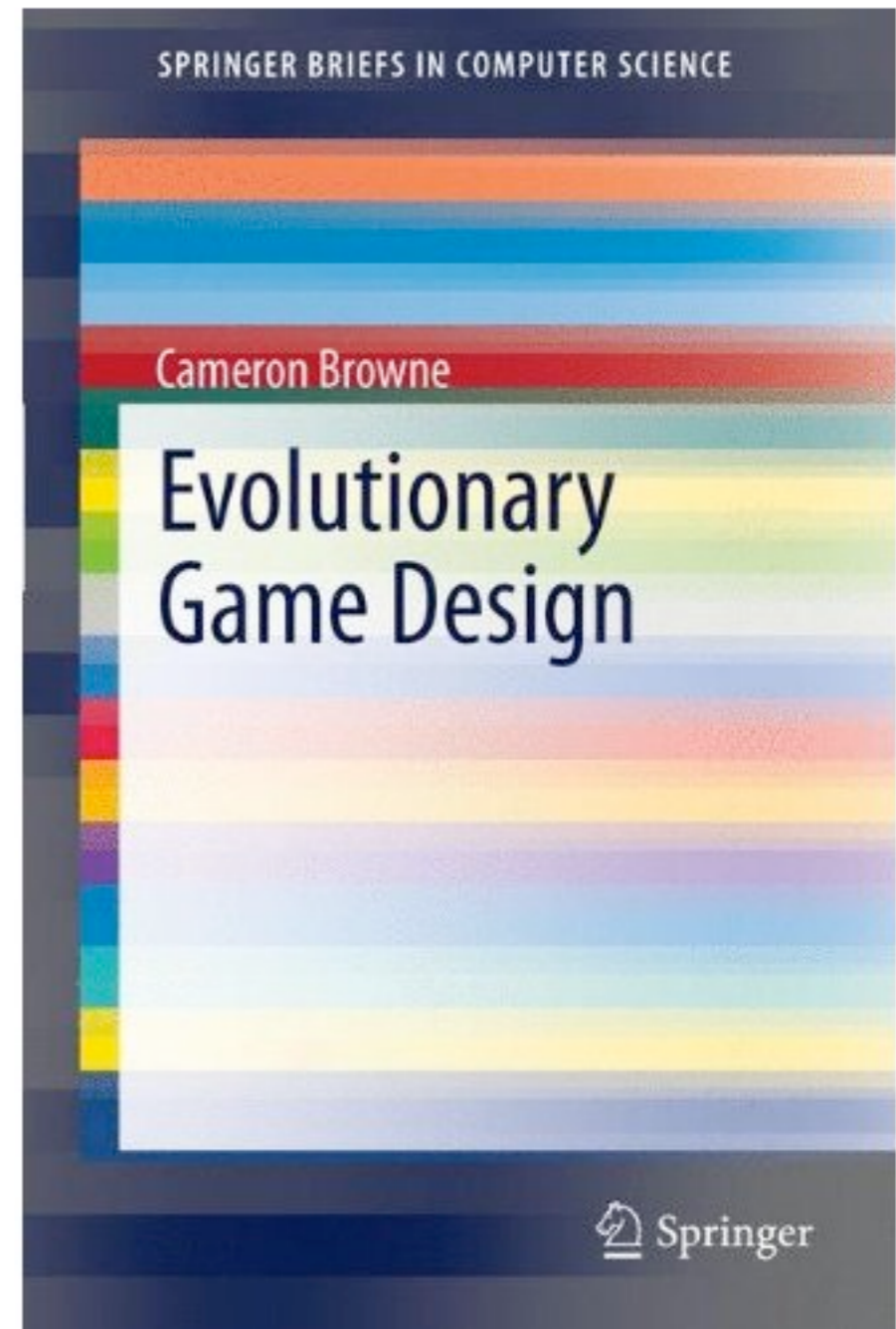
2007: Games generated
2009: Games published
2011-12: Full impact seen

Publications over last 12 months describe this impact

C. Browne (2011)
Evolutionary Game Design
Springer, Berlin

Representation

Games described as *s-expressions*

Represent rule trees

Structured, high-level, human readable

Model human understanding of games
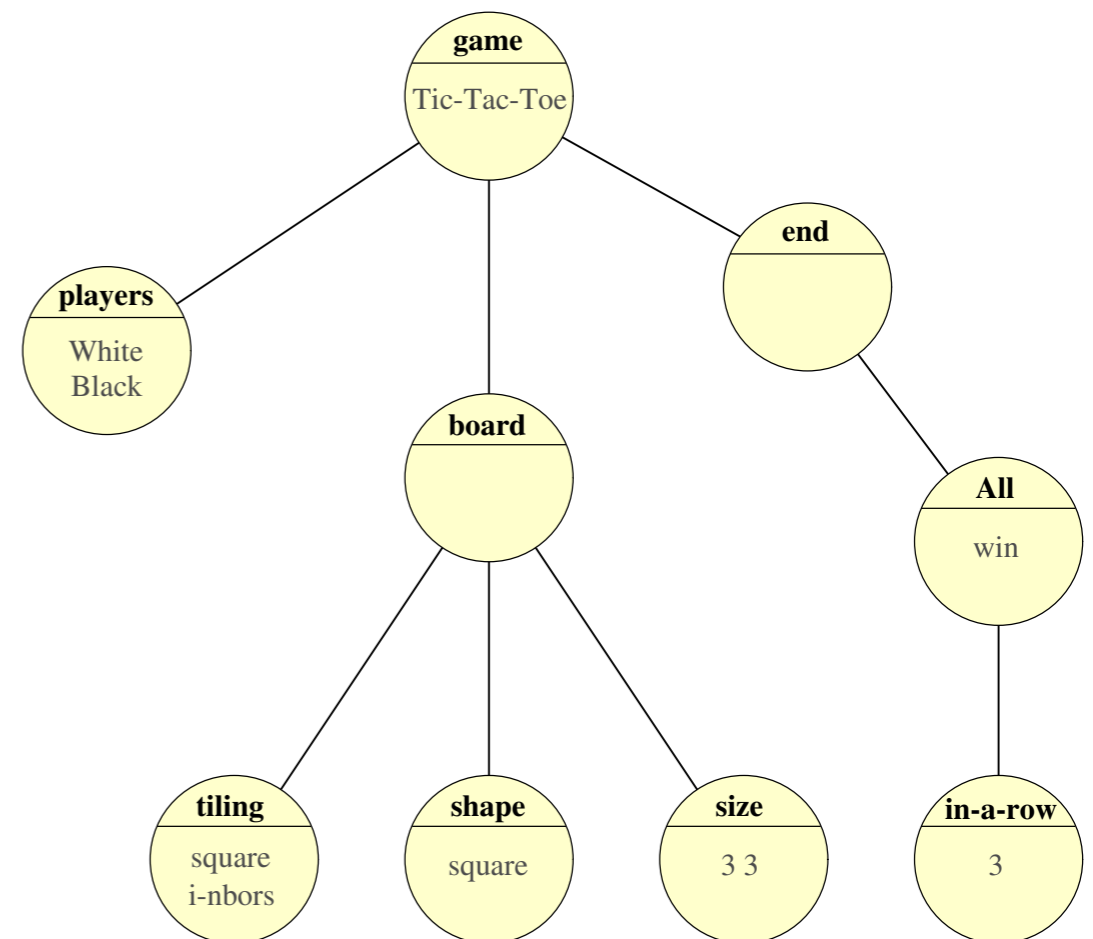
```
(game Tic-Tac-Toe
    (players White Black)
    (board
        (tiling square i-nbors)
        (shape square)
        (size 3 3)
    )
    (end (All win (in-a-row 3)))
)
```

Operation

Standard GP operators:
‣ Crossover
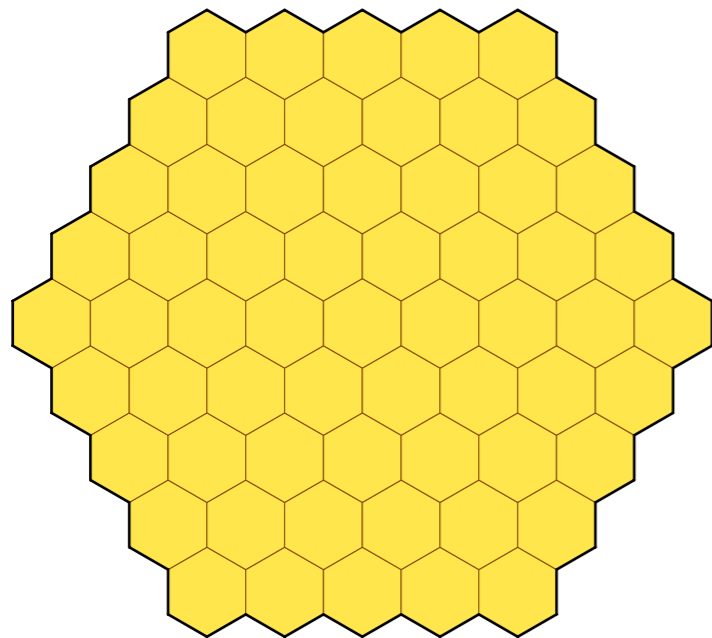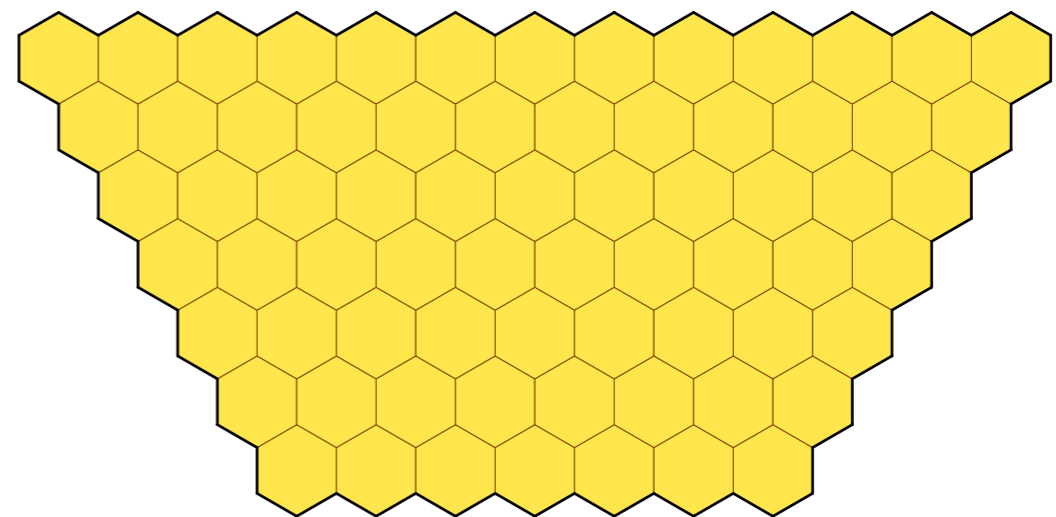‣ Mutation

Fitness: Self-play AI trials

Results

79 source games (initial population)
1,389 valid children (final population)
19 playable games (~1.37%)

Measured for quality
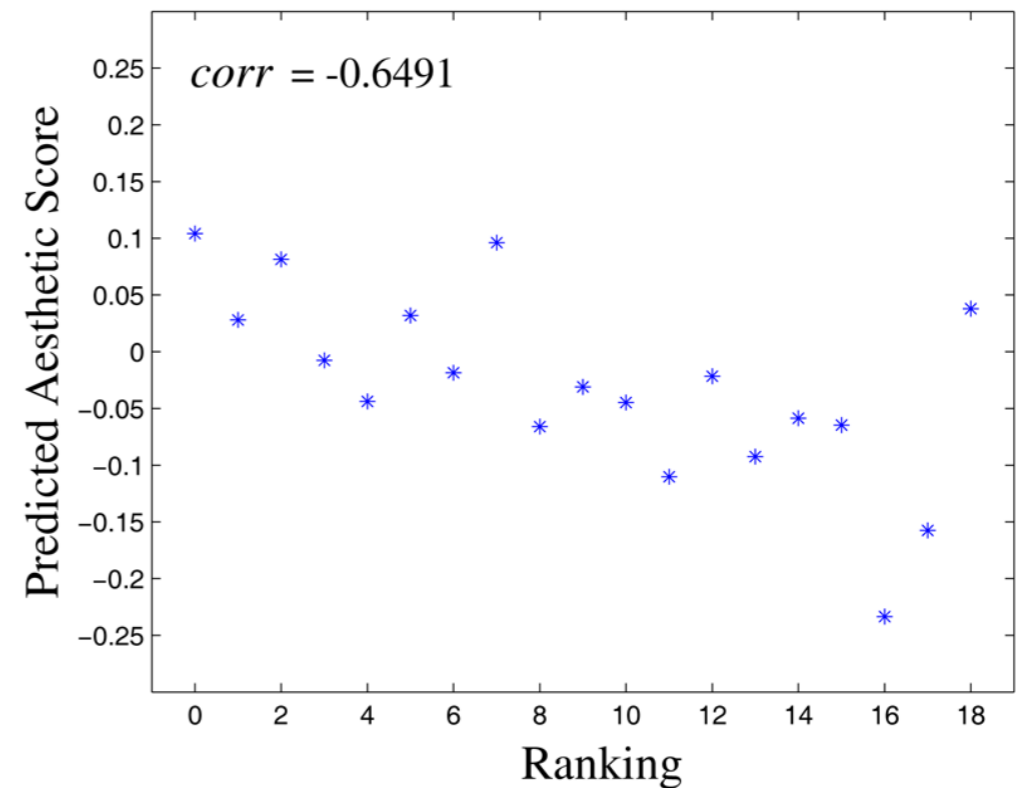Good correlation with player rankings

Two best games published:

Yavalath

Ndengrod
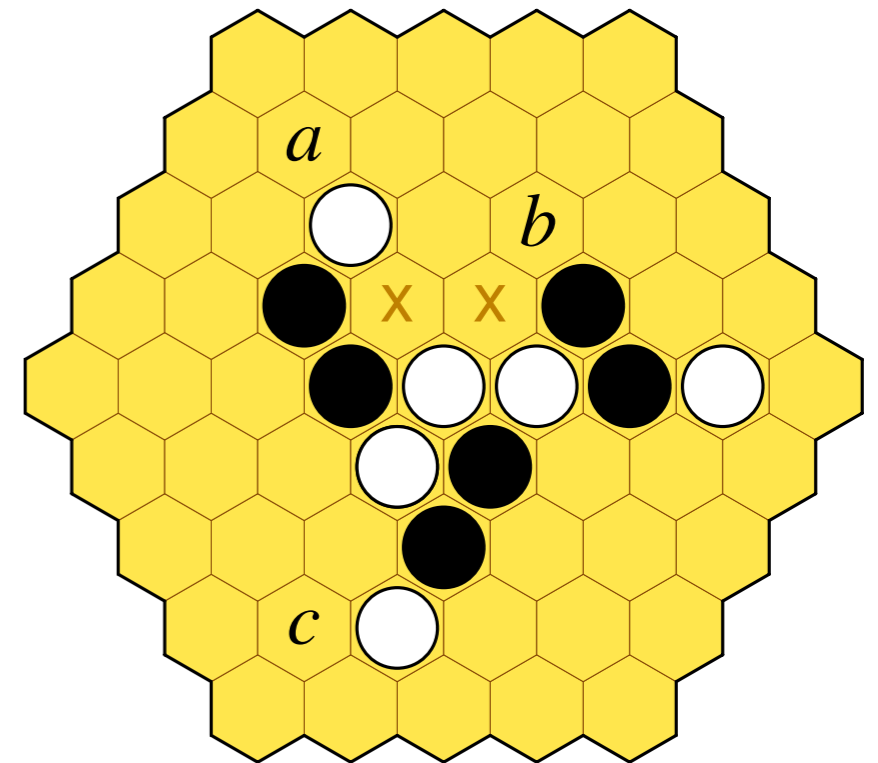(aka Pentalath)

Yavalath

```
(game Yavalath
    (players White Black)
    (board (tiling hex)(shape hex)(size 5))
    (end
        (All win (in-a-row 4))
        (All lose (in-a-row 3))
    )
)
```
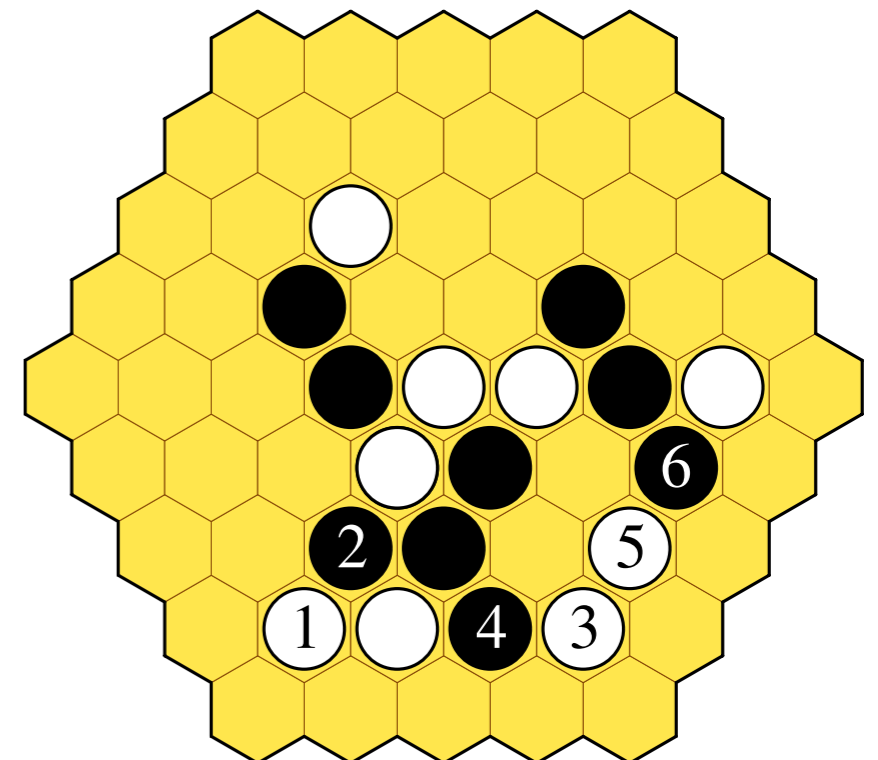
Win with line of 4 but lose with line of 3

Ranked #2 by players, #4 by LUDI

Subverts familiar *N*-in-a-row genre

Forcing moves: planning with certainty

Puzzle: White to play.

Quality

BoardGameGeek (BGG) database: www.boardgamegeek.com
Foremost online community for board game players and designers

400,000+ users (educated voters)
52,000+ games (all known board games)
4,300+ games in "Abstract Games" category

Yavalath ranked #99 (August 2011)
Top 2.5% of abstract games ever invented (99th out of 4,300)
Top 4% of abstract games invented in 2007 (8th out of 200)

  #3   Go
 #45   Chess
 #99   Yavalath
#112   Backgammon
#267   Othello
#539   Mastermind
#546   Chinese Checkers

nestorgames

Published Yavalath in 2009

First game in catalogue (now 80+)

Yavalath still flagship product

Favourite exhibition game:
‣ Easy to learn
‣ Addictive ("aha!" moment)

Works as a three-player game

Deluxe 3rd anniversary edition (~$200)

nestorgames www.nestorgames.com

Impact

Yavalath has directly inspired new games:
‣ Tritt, Cross, Tailath, Morro, Epsilon, ...

Yavalath has inspired new game types:
‣ Group of size N but not size N-1
‣ Connect N sides but not N-1 sides

New sub-genre: *N but not sub(N)*

Improvement Over Prior Art

Following Yavalath, experienced designer announced similar idea:
‣ Line of 5 but not 4 on square grid
‣ Didn't work, never released, shelved years ago

LUDI found a rule set that worked, where a human designer had failed

Game Design Principles (A)

Yavalath implicitly captures the following principles:

1. Familiar but Novel

Familiar = Easy to learn
   Novel = Keeps game interesting to play

Hard balance to achieve

2. Rule Tension

Conflicting rules (4 = good but 3 = bad)
Can't just extend lines
Must weigh up pros and cons of every move

Ndengrod


```
(game Ndengrod
   (players White Black)
   (board (tiling hex)(shape trapezium)(size 7))
   (pieces
      (Piece All
         (moves
            (move
               (pre (empty to))
               (action push)
               (post (capture surround))
) ) ) )
   (end (All win (in-a-row 5)))
)
```
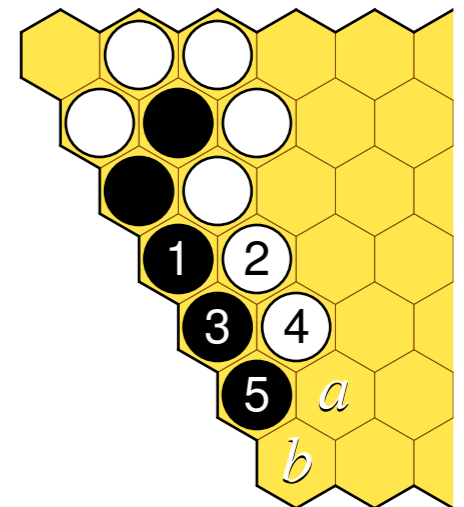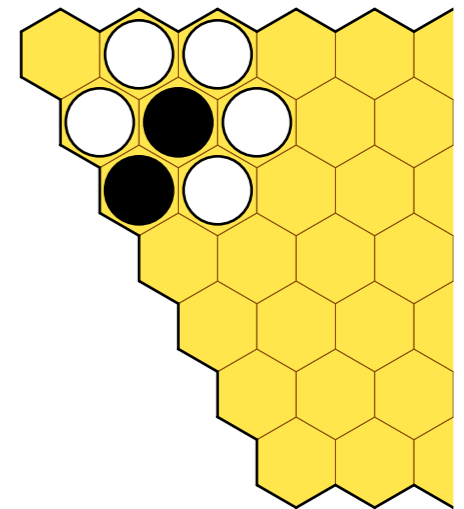

Go-like surround capture, win with 5-in-a-row

Ranked #1 by players and LUDI

Interesting: deeper than Yavalath but harder to learn

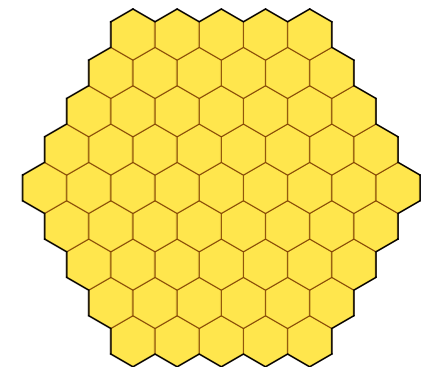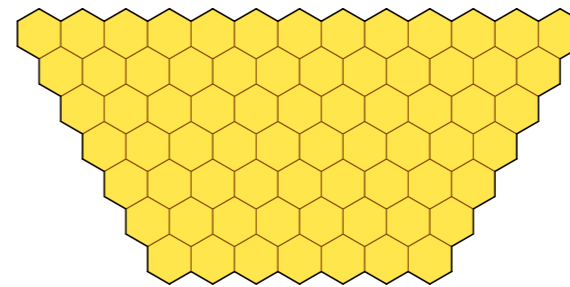Hexagonal Go variant that works (difficult!)
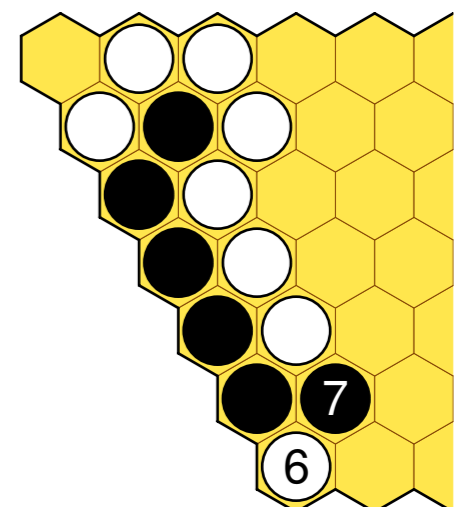
Game Design Principles (B)
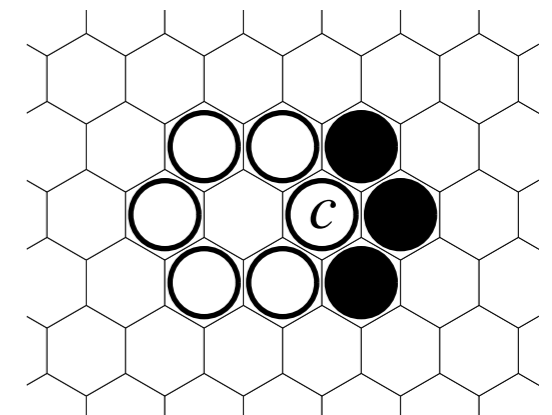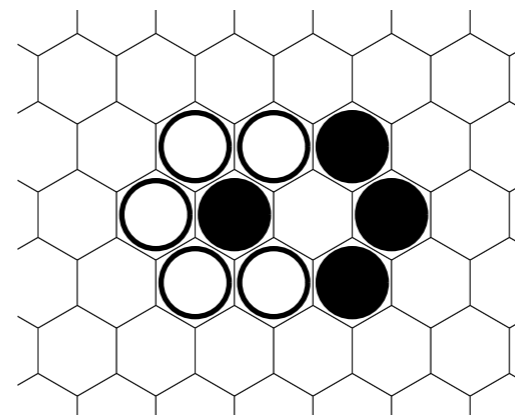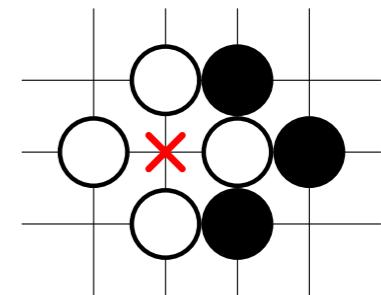
Ndengrod implicitly captures the following principles:
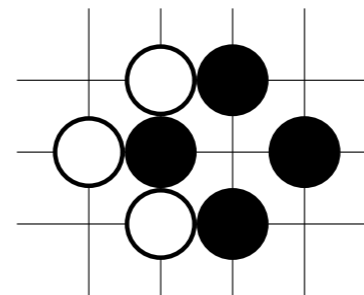
3. Acute Corners Add Variety

Designed on trapezoidal board
Released on Yavalath board (2009)
Re-released on original board (2012)
LUDI knew best!

4. No *Ko* on Hexagonal Grids

Ndengrod works without a *ko* rule
Essential for Go (avoids cycles)
Not needed on hexagonal grid!
LUDI implicitly (re)discovered this

Result is Human Competitive

Results satisfy the following criteria:

C) Result >= result placed in an expert database

Yavalath ranked in top #100 of abstract board games ever invented
BoardGameGeek (BGG) database
Ranked higher than many famous games:
‣ Backgammon, Halma, Checkers, Chinese Checkers, etc.

D) Result publishable in its own right

Yavalath and Ndengrod successfully published

F) Result >= result considered achievement when first discovered

Ranked higher than many games considered achievements:
‣ Othello, Mastermind, Abalone, etc.

Result is Best

Game design is an art as much as a science

Game design is a very human craft

LUDI was able to:
‣ Evolve new and interesting games
‣ Inspire a new sub-genre of games
‣ Find good solutions to problems encountered by human designers
‣ Implicitly capture several principles of good game design
‣ Yield insights that have surprised its designer

Thank you!