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

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

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
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)
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: \(N \text{ but not } \text{sub}(N)\)

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
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

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

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!)
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 $\geq$ 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 $\geq$ 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!