AI-Assisted Game Design: a diverse research challenge

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Outline

- The Challenge
  "How can AI be used to assist in game design?"
- Potential Research Topics and Examples:
  - Procedural Content Generation
    "How can AI be used to generate diverse worlds and elements therein?"
  - Game Analysis for Game Improvement
    "How can AI techniques leverage mathematical insight from game data to improve a game's design?"
  - AI-Assisted Game Invention
    "How can AI search a space of possible combinations of rules to find a set with good quality play?"
  - Other applications of AI techniques to Game Design
- Conclusion

What Is AI-Assisted Game Design?

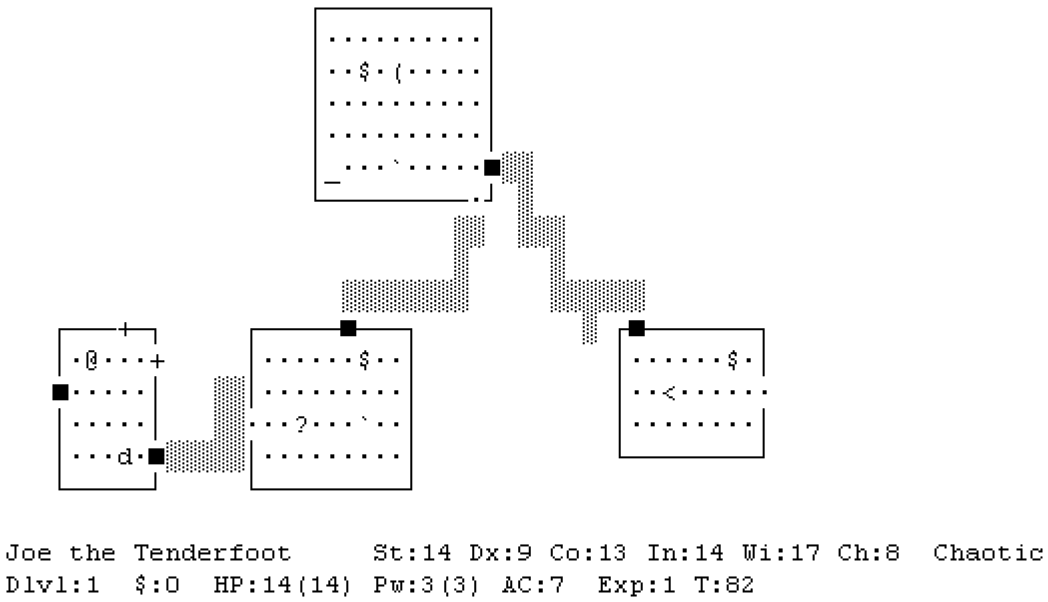
- What distinguishes **AI-Assisted Game Design (AIAGD)** from **AI game play** is that the results of an AI technique are applied to the *design of the game itself*.
- AIAGD *includes* but is not the same as Procedural Generation
- AIAGD also includes:
  - Game Analysis for Game Improvement
  - AI-Assisted Game Invention
  - Other application of AI techniques to Game Design

AAAI/EAAI Mentored Undergraduate Research Challenge

- Teams:
  - At least one faculty member serving as a mentor and peer-reviewer.
  - At least one undergraduate student researcher being mentored.
  - Mixed teams with graduate students are permitted.
- Submission deadline: ~September 2021 at the AAAI-22 full paper deadline
- Accepted papers will be presented at EAAI-22:
  - Collocated with AAAI-22: https://aaai.org/Conferences/AAAI-22/
  - Vancouver Convention Centre, Vancouver, British Columbia, Canada, February 22 - March 1, 2022

Procedural Content Generation

- Name some games you have played where the computer has generated content of the game, e.g. landscape, world elements, etc.?
- Excellent examples from Prof. Presser's colloquium on PCG: http://cs.gettysburg.edu/~cpresser/colloquia/pcg/PCG.pdf



https://en.wikipedia.org/wiki/Procedural_generation#/media/File:Nethackscreen.gif

Common Examples

Minecraft

No Man’s Sky

Slides credit: Clifton G. M. Presser

Uncommon Example: Dwarf Fortress

- Simulates History: civilizations, wars, religion etc.

Slide credit: Clifton G. M. Presser

Nerfing and Buffing

- Have you ever played a game where a game element was significantly over-/under-powered?
- Have you ever had a game element “nerfed” (made weaker), or “buffed” (made stronger) in a new game version/patch?
- How has this affected your play experience?

Game Data Analysis for Game Improvement

- Discern over-/under-powered (over-/under-used) game elements to nerf/buff
  - Magic the Gathering – recent card bannings (20 in the last 2 years)
  - Fortnite – nerfing/buffing over-/under-powered weapons

Should Players be Primary Playtesters?

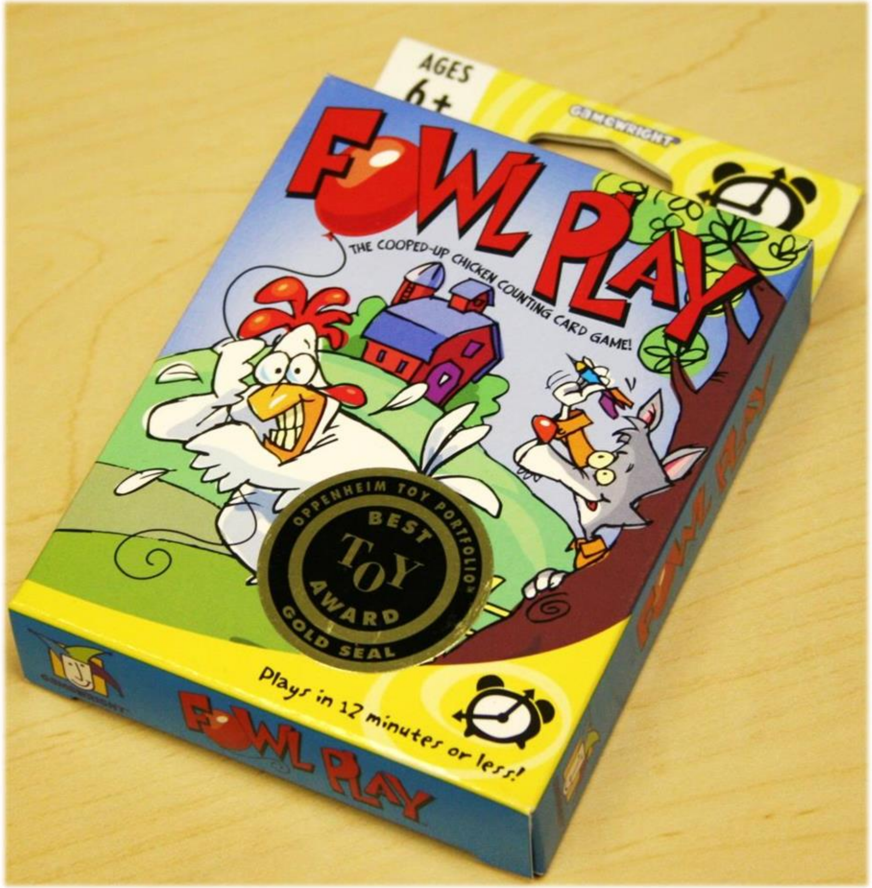
- While players being involved in development feedback and design is an important modern dynamic, e.g. Valheim, there are many games that are released with a feel of being unfinished or not thoroughly tested.
- There is great potential for AI players to find and exploit bugs in game physics:
  - OpenAI Hide and Seek https://www.youtube.com/watch?v=Lu56xVlZ40M&t=66s (1:06 – 3:18)
  - Q*Bert: https://youtu.be/wm8tK91k37U?t=131 (2:11 – 2:39)
- In general, AI players could preemptively expose bugs, under-/over-used game elements, and other ways in which the design is “broken”.

Red Light as AI-Assisted Improvement of Fowl Play

- T. Neller, M. Malec, C. Presser, F. Jacobs. **Optimal, Approximately Optimal, and Fair Play of the Fowl Play Card Game**, in the Proceedings of the 8th International Conference on Computers and Games CG2013
  - Resulted in approximately fair Poker chip variation “Red Light”

Fowl Play

- Designed by Robert Bushnell and published by Gamewright in 2002
- Object: Be the first of 2+ players to reach a given goal score.
  - We consider 2 players, 50 point goal case.
- Materials: Shuffled 48 card deck with
  - 42 chicken cards (each incrementing turn total)
  - 6 wolf cards (each causing loss of turn total)



Fowl Play (cont.)

- On each turn, draw one or more cards until:
  - you draw a wolf and score no points, or
  - you hold and score the number of chickens you've drawn.
- After the last (6th) wolf is drawn, reshuffle all cards.

Optimizing Fowl Play for Fairness

- Given an ability to analyze perfect play and win probabilities with Value Iteration, we can
  - vary the number of good (chicken) and bad (wolf) outcomes,
  - compute optimal play for each game,
  - compute komi optimizing fairness, and
  - thus optimize the game design for fairness.
- With our optimized game of Red Light, the first player wins 50.001% assuming optimal play.

Red Light

- Object: Be the first of 2 players to reach 50 points. The 2nd player begins with 1 point.
- Materials: 28 poker chips in a bag with
  - 24 green “green light” chips (each incrementing turn total)
  - 4 red “red light” chips (each causing loss of turn total)

Red Light (cont.)

- On each turn, draw one or more chips until:
  - you draw a red light and score no points, or
  - you hold and score the number of green lights you've drawn.
- After the last (4th) red light is drawn, all chips are returned to the bag and reshuffled.
- Alternate materials: Standard ("French") deck of playing cards using Ace (red light) and 2-7 (green lights) of each suit.

Design as Optimization: Rook Jumping Mazes

- Todd Neller, Adrian Fisher, Munyaradzi T. Choga ‘12, Samir M. Lalvani ‘13, and Kyle D. McCarty ’11. Rook Jumping Maze Design Considerations, in van den Herik, H. Jaap, Iida, Hiroyuki, and Plaat, Aske, eds., *LNCS 6515: Computers and Games, 7th International Conference, CG 2010, Kanazawa, Japan, September 24-26, 2010, Revised Selected Papers*, Springer, 2011, pp. 188-198.
- Some attribute the creation of the Rook Jumping Mazes (RJM) to the great puzzle innovator Sam Loyd, who published a Queen Jumping Maze allowing diagonal moves in 1898. Few maze designers have the skill to create them.
- Let’s look at an example…

Example Rook Jumping Maze

- **Specification**: grid size, start state (square), goal state, jump numbers for each non-goal state.
- ***Jump number:*** Move *exactly* that many squares up, down, left, right. (*Not* diagonally.)
- **Objectives**:
  - Find a path from start to goal.
  - Find the shortest of these paths.

3	4	1	3	1
3	3	3	G	2
3	1	2	2	3
4	2	3	3	3
4	1	4	3	2

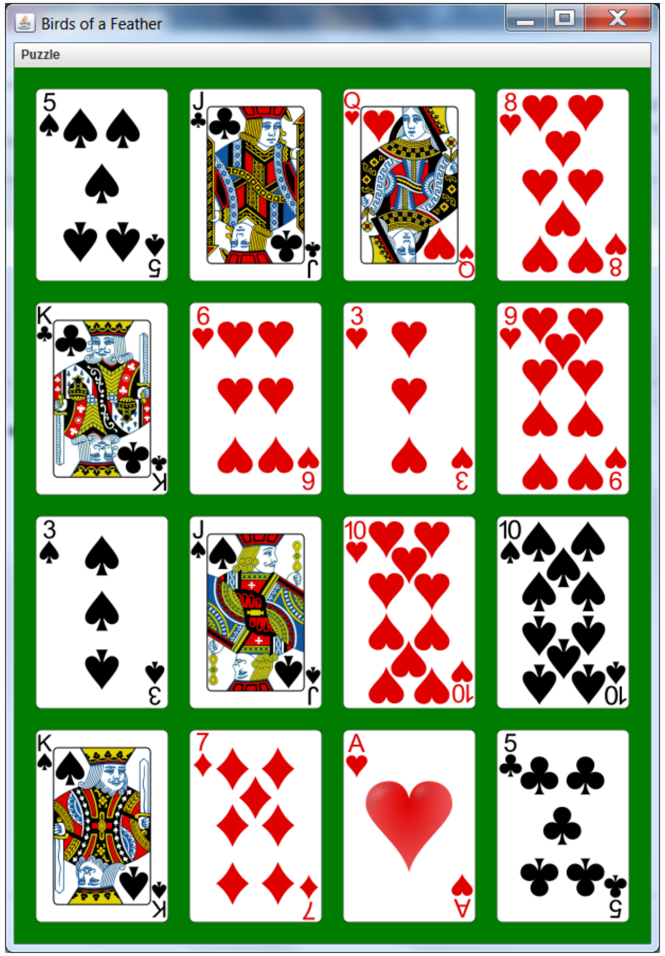
Computer Generation of RJMs

- Stochastic Local Search: Iteratively change a single random jump number, accepting improvements, and usually rejecting changes for the worse according to an “energy” measure we seek to minimize.
- Energy = puzzle badness; subjective and hard to express
- Iterative puzzle design generations suggesting refinements to “energy”:
  - Goal Reachability, Reaching States, Reachable States, Black Holes, and White Holes
  - Shortest Solution Uniqueness
  - Minimum Solution Path Length
  - Etc.

Birds of a Feather (BoaF)

- “Birds of a feather flock together.”
- Designed August 9, 2016
- **Materials**: a standard, shuffled 52-card deck
- **Setup**: Deal cards singly, face-up into a grid (e.g. 4-by-4).
- **Object**: Form a single stack of all cards.
- **Play**: A player may move one stack of cards onto another stack of cards in the *same row or column* if the cards on top of the stacks have either
  - (1) the *same suits*, or
  - (2) the *same* or *adjacent ranks*. Aces are low and not adjacent to kings, so rank adjacency is according the ordering A, 2, 3, …, J, Q, K.

Birds of a Feather Example with Solution

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TS-9H AH-TH AH-3H
AH-QH 6H-7D JS-JC
KS-3S KS-KC 5S-KS
6H-5C 5S-TS AH-8H
6H-AH 5S-6H 5S-JS
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Generation of Difficult Interesting BoaF Deals

- Todd Neller, Daniel Ziegler ’21. [Computer Generation of Birds of a Feather Puzzles](), in the Proceedings of the 33rd AAAI Conference on Artificial Intelligence (AAAI-19), January 27 – February 1, 2019, Honolulu, Hawaii, USA, AAAI Press, Palo Alto, California, USA, pp. 9693-9699.
- Key insight: The most difficult, interesting BoaF puzzles we generated maximized puzzle tension at the halfway point to the solution.
- Many good puzzles have an “hourglass” structure of easy-tense-easy effort through the solving process, e.g. Sudoku, FreeCell, the Devil’s Claw.

Puzzlewarehouse.com image

Game Tension

- Game Tension, according to Cameron Browne, can be estimated as the probability that a random player will make a wrong choice.

Browne informally described tension as follows:

> Tension is related to the amount of impact that players' choices have on the outcome of the game.

Browne further proposes a simple metric for estimating the tension T in puzzle state S:

$$T(S) = 1 - \frac{M_{S_w}}{M_S}$$

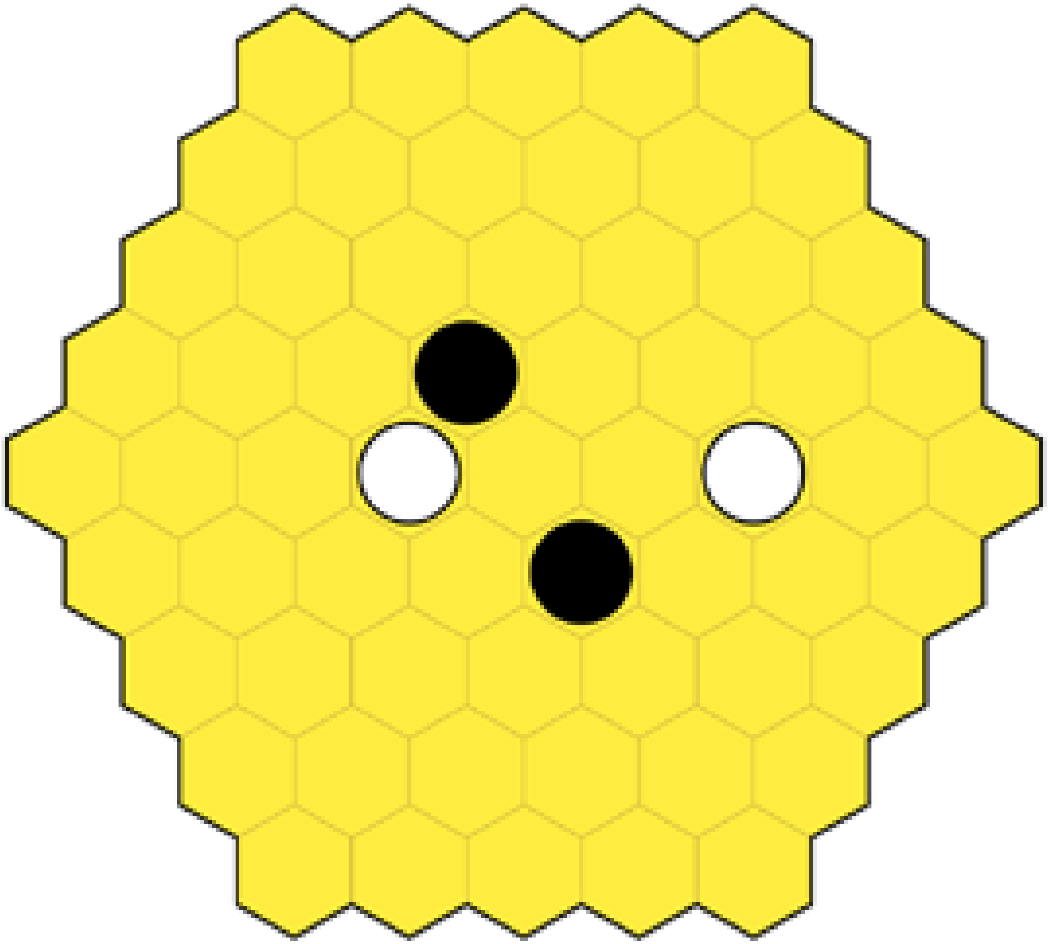
where M_S is the number of moves available in S and M_{S_w} is the number of winning moves available in S.

AI-Assisted Game Invention

- Cameron Browne's work
  - Digital Ludeme Project (http://ludeme.eu/) - seeks to express a wide variety of historical games according to game units called "ludemes".
    - The project seeks to "represent games as structured sets of *ludemes* (units of game-related information)", e.g. objectives (capture all pieces, reach position, form a line of length *n*), actions (jump capture, place piece), etc.
  - Evolutionary algorithmic approach to computationally design the game Yavalath (Browne, 2011, pp. 75-85; http://cambolbro.com/games/yavalath/).
  - See also Browne's *Game and Puzzle Design Journal* (http://gapdjournal.com/)

Yavalath

- Rules and examples from: http://cambolbro.com/games/yavalath/
- Rules:
  - The board starts empty.
  - Two players take turns adding a piece of their color to an empty cell.
  - **Win** by making a line-of-4 (or more) pieces of your color.
    Lose by making a line-of-3 pieces of your color beforehand.
    Draw if the board otherwise fills up.
- White to win with which move?
- Annotated sample game at link above.



Mentored Undergraduate Research Challenge

- A limited number of papers will be accepted for publication and presentation at EAAI-22 that
  - exemplify high-quality scholarly writing, and
  - demonstrate creative application of AI to AI-Assisted Game Design.
- As mentioned, this can take many forms, including but not limited to:
  - Existing game improvement through AI game analysis,
  - New game design through AI search in a design space,
  - Adaptive technologies shown empirically to improve player experience, and
  - AI procedural generation of game play elements.
- Teams must include at least one faculty mentor and at least one undergraduate. Faculty mentors will be expected to review. (Contact Todd Neller <tneller@gettysburg.edu> to register teams.)

The AI-Assisted Game Design Challenge

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https://sigai.acm.org/static/aimatters/6-3/AIMatters-6-3-04-Neller.pdf

Or search “AI Matters”

Questions?