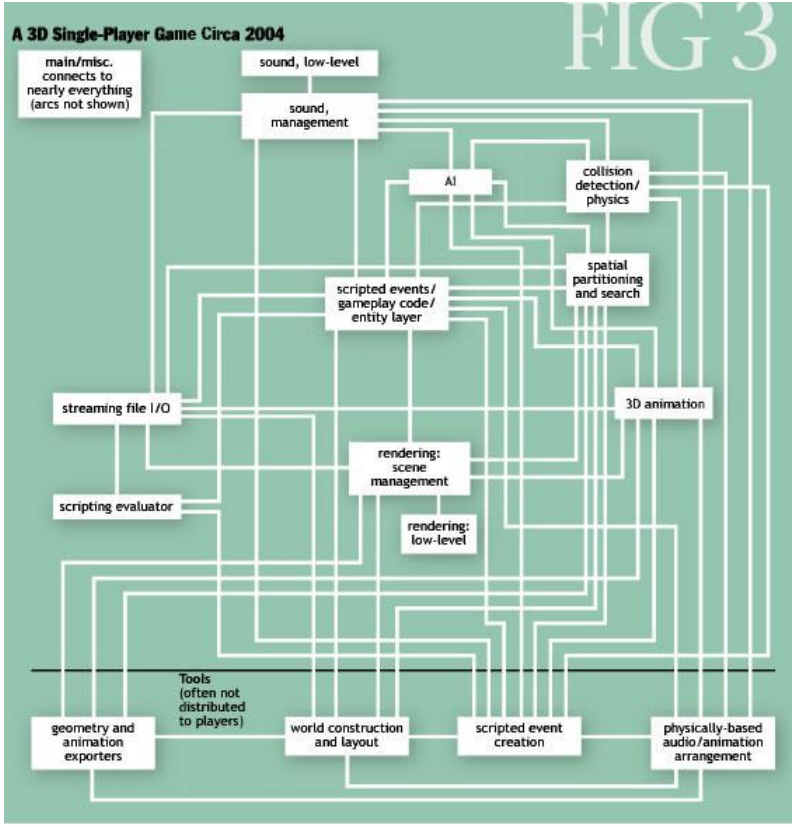
Promoting Human Collaboration in Procedural Content Generation Tools for Game Development

Benjamin Burgess

Introduction

- **Game development is a difficult and time consuming process**
- Procedural content generation (PCG) games save time but may result in lower quality
- Mixed initiative design efforts can be a good compromise



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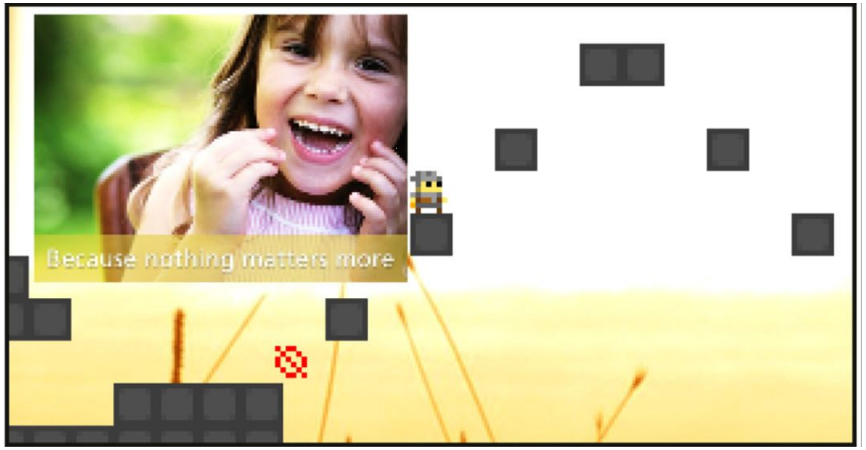

Liapis et al (2019)

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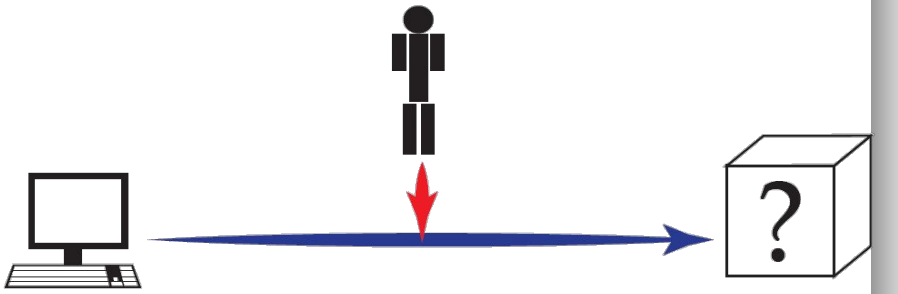

http://antoniosliapis.com/articles/pcgbook_mixedinit.php

Outline

- **Background**
  - The six facets of game design
  - Example PCG games and analysis of their approach styles
- Evolutionary Dungeon Designer (EDD)
  - Genetic Algorithm basics and introduction of variant
  - Implementation details
  - Study findings
- Morai Maker
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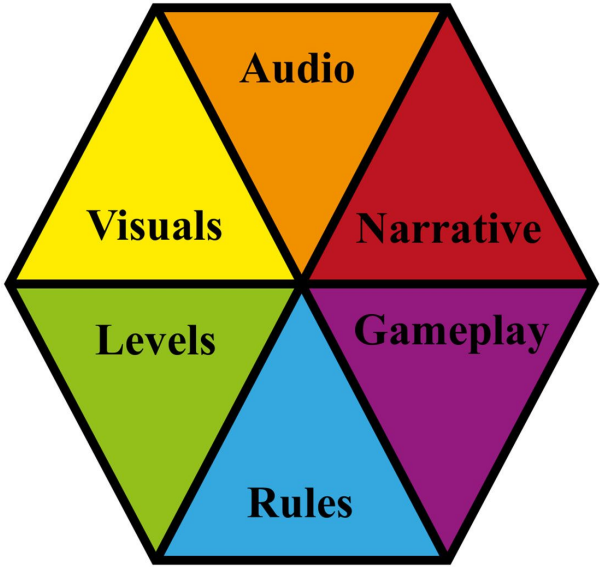
  - Study findings
- Conclusions

The six facets of game design

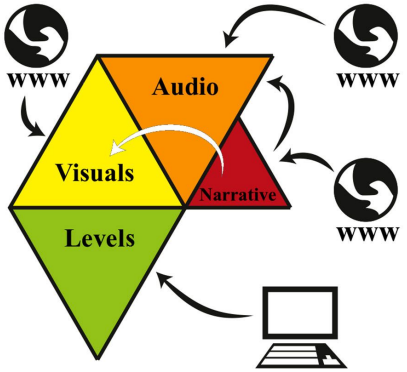
- Framework used to compartmentalize different aspects of game design
- Originally created as a means of directing the automated creation of entire games
- Useful for discussing PCG approach styles

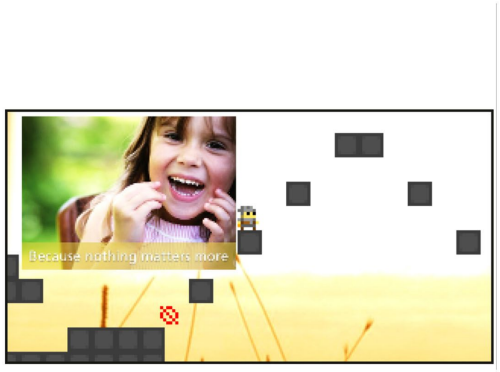


Liapis et al (2019)

Angelina

- Creative software developed from 2011-2016 that creates simple platformer games
- Scrapes information from online articles (things like news sites)
- The mood of the article is evaluated and used to choose image backgrounds and sound-bytes based on the article contents

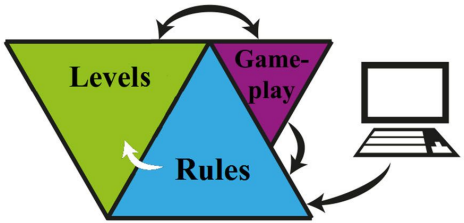




Liapis et al (2019)

Mechanic Miner

- Generates game rules by altering the source code of a platformer game
- Levels are generated according to the new source code
- Level playability is ensured by an agent performing random actions



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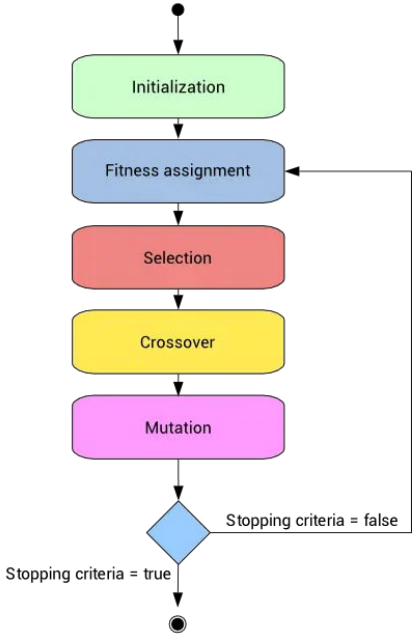
Genetic Algorithm Overview

- Genetic algorithms seek to generate high-quality solutions to problems by mimicking biological processes
- The objective function is used to determine a candidate solution's quality
- Fitness functions measure the quality of an individual's properties
- Higher quality solutions are more likely to be selected and pass on their properties



https://www.neuraldesigner.com/blog/genetic_algorithms_for_feature_selection

Feasible-Infeasible Two-Population Genetic Algorithm (FI-2PopGA)

- Variant of genetic algorithm
- Maintains two populations of candidate solutions to boost solution diversity
  - Feasible - solutions that satisfy problem constraints
  - Infeasible - solutions that don’t
- Process remains largely the same, save for selection
  - Feasible individuals are selected to increase payoff while disregarding potential constraint violations
  - Infeasible individuals are selected with the goal of repair while disregarding potential payoffs

The Evolutionary Dungeon Designer

- Mixed-initiative PCG tool used to create dungeon levels
- Uses FI-2PopGA to generate room suggestions
  - Feasible population includes levels that satisfy playability constraints
  - Infeasible population includes those that don't
- Fitness functions consist of things like corridor lengths matching constraints
  - $Q\text{corridor}(c) = min(1.0, Area(c) / T\text{corridorlength})$

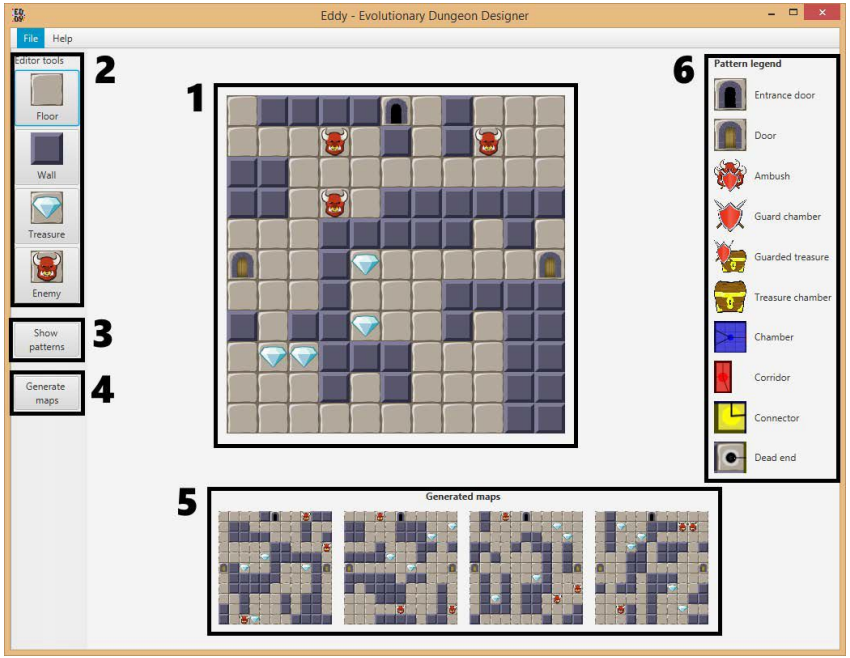
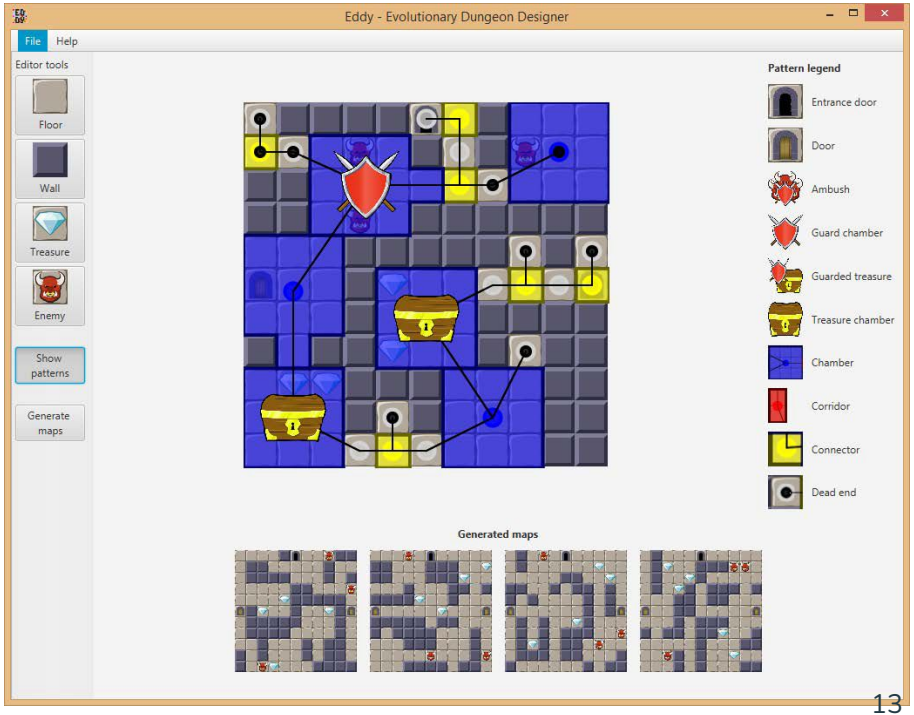


Image: Baldwin et al (2017)

The Evolutionary Dungeon Designer

- Also uses micro and meso patterns to determine level quality
  - Micro patterns: chambers, corridors, joints, turns
  - Meso patterns: treasure chamber, guard chamber, ambush, dead-end, guarded treasure
- Users can pick from generated level suggestions, make edits, and generate more level suggestions and so on until satisfied



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The Evolutionary Dungeon Designer: First User Study Details

- Conducted in order to determine the relevance of the mixed-initiative component and discover useful features for future iterations of the software
- Five people from the game development industry
  - Level design
  - Engine programming
  - Animation
  - User research
- They made three increasingly difficult 11X11 rooms that would be part of the same dungeon level then took part in a structured interview

The Evolutionary Dungeon Designer: First User Study Findings

- Four of them believed EDD to be an interesting and time-saving tool for dungeon design
- One participant tried to design their level without adhering to established design patterns
- Two participants wished to be able to modify existing design patterns
- Three participants believed that manually altered content should not be affected by the evolved suggestions

The Evolutionary Dungeon Designer: Second User Study Details

- A follow-up user study was conducted with another five game developers (one of which participated in the previous study)
  - User 1: 10+ years as a data scientist and user experience researcher
  - User 2: 6 months as a project coordinator of eSports events
  - User 3: 6 years as a user experience researcher and biometrics expert
  - User 4: 9 years as a senior user experience researcher
  - User 5: 3 weeks as game user researcher
- They designed a 3X3 dungeon with a 10 minute time limit and then participated in a structured interview

The Evolutionary Dungeon Designer: Second User Study Findings

- They found that their main goal of establishing a mixed-initiative tool with flexible human and computer design roles only partially achieved
- Participants found it overall good and intuitive, with room suggestions and whole dungeon navigation being deemed particularly useful
- Users still expressed a desire for more control over EDD when designing levels

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Morai Maker

- Morai Maker is a mixed-initiative level creation tool
- Users work collaboratively with an AI agent to create Super Mario Bros-like platformer levels
- Three different AI used
  - Markov Chain - focused on hyper local changes (2X2 grid)
  - Bayes Net - wider level focus (16 grid points)
  - Long Term Short Term Memory Recurrent Network - focuses on most of the level

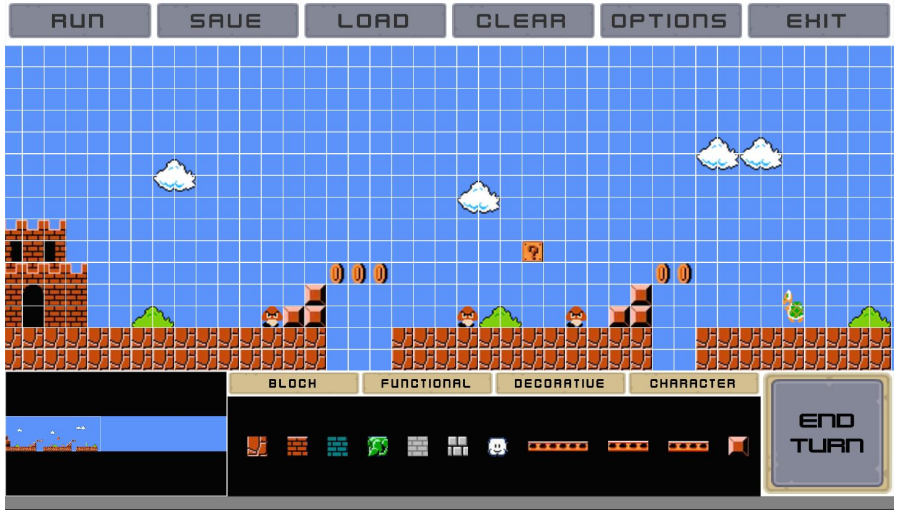

Image: Guzdial et al (2019)

Morai Maker: First User Study Details

- Conducted to derive design lessons about the interface and AI system
- Included 91 participants
  - 61 in 18-22 age range
  - 19 in 23-33 age range
  - 1 in 34-55 age range
- Participants were given a short tutorial on the tool's function and took part in two design sessions where they created two levels alongside a randomly selected AI partner
- They were required to interact with their AI partner at least once per session

Morai Maker: First Study Findings

- Results split into three conditions based on the pair of AI partners interacted with
  - Each pair of partners was ranked based on experiential features
  - Rankings for each pair was inconsistent
- No single partner could meet all user expectations
- Participant levels were significantly different than traditional Super Mario Bros Level Structure
- Participants didn’t understand how their AI partner worked

Morai Maker: Second User Study Details

- Second study run with updated version of Morai maker based on a semi-markov Decision Process with a three layer Convolutional Neural Network as the AI agent
- Sought to answer three questions:
  - Does leveraging active learning to adapt the AI partner to a user allow a tool to better serve level designer needs?
  - Can Explainable AI allow users a better understanding of the AI, and thus allow greater utilization of the tool?
  - Will the overall changes benefit designer experience?

Morai Maker: Second User Study Methods

- Participants included 14 game designers who were given a run-down of the tool and were allowed to ask any questions they may have about the software
  - 1 aged 18-22
  - 11 aged 23-33
  - 2 aged 34-54
- Participants again designed two levels but under the new single agent system
- They were then asked questions about their experience with the tool
  - Did they prefer the AI behavior in the first or second session?
  - Would they prefer the tool with or without the AI partner?
  - Did they feel that the agent was collaborating with them?
  - Did they feel the agent was adapting to them?
  - Were explanations about AI behavior helpful if requested?

Example User Levels

- Each pair of levels is made by one of the participants

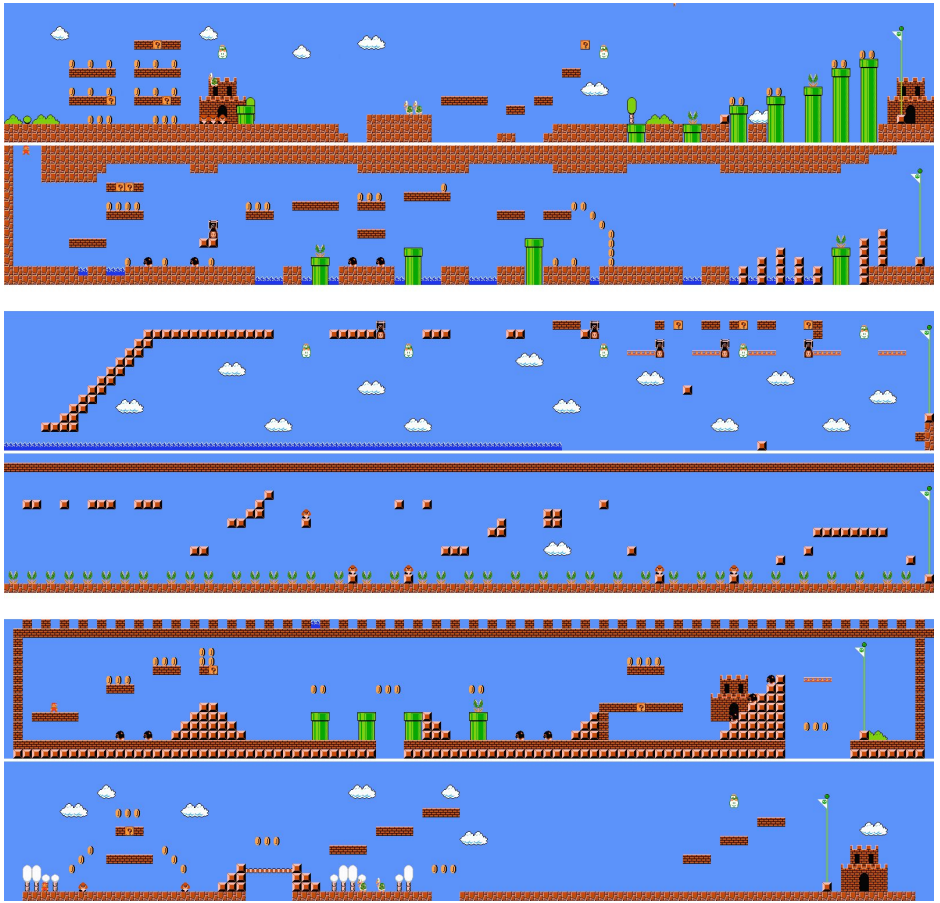

Image: Guzdial et al (2019)

Morai Maker: Second User Study Findings

- Tool with AI preference
  - 9 participants preferred the tool with the AI partner
  - 2 preferred it without
  - The rest had no preference
- Two major strategies to get value from the tool were identified
  - Unintentional inspiration source
  - Intentional means of getting over lack of ideas
- No meaningful answer found regarding explainable AI

	First	Second
Most Fun	5	9
Most Frustrating	8	6
Most Aided	5	9
Most Creative	5	9
Preference	6	8
	Yes	No
Collaborating	7	7
Adapting	9	5

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Conclusions

- PCG tools can allow for faster development of game content at a potential loss in quality
- Mixed-Initiative PCG tools seem like a promising compromise between quality and speed
- Initial surveys suggest that people find value in such tools
- More and larger studies investigating these tools would be helpful

Questions?

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