Mech-Elites

Illuminating the Mechanic Space of GVGAI

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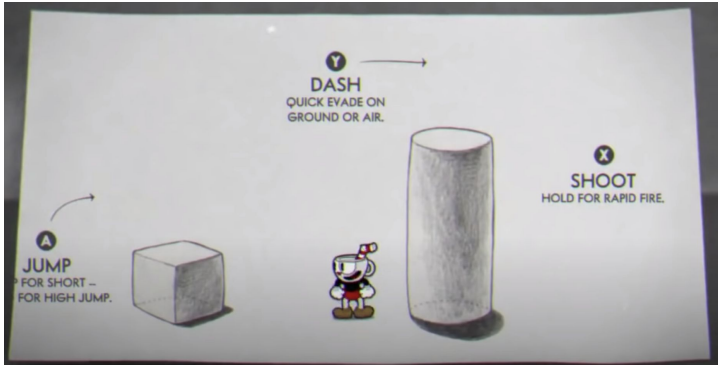
mechanic (n)

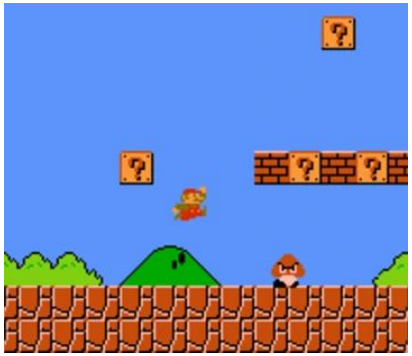
Any event in the game that involves game entities and changes the game's state

Concept

- Identify the mechanics of a game
  - i.e. jumping, collecting a key, attacking an enemy
- Tutorial levels center around these mechanics
- Have an AI identify these mechanics and generate levels



Tutorial Level from Cuphead
(StudioMDHR, 2017)



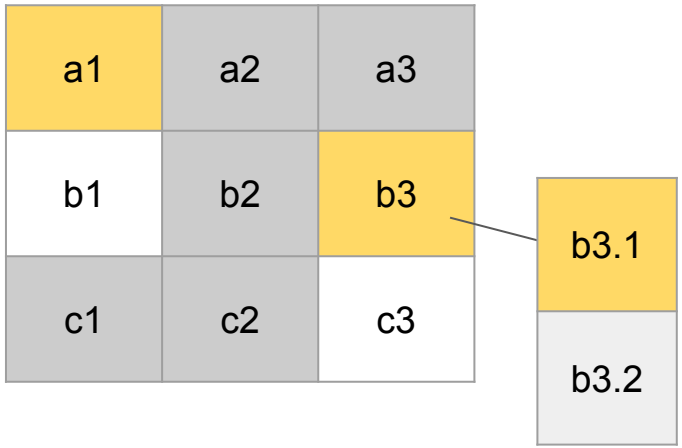
World 1-1 from Super Mario Bros
(Nintendo, 1985)

Background

- Map-Elites
  - Map of *n*-dimensions based on a feature representation

a1	a2	a3
b1	b2	b3
c1	c2	c3

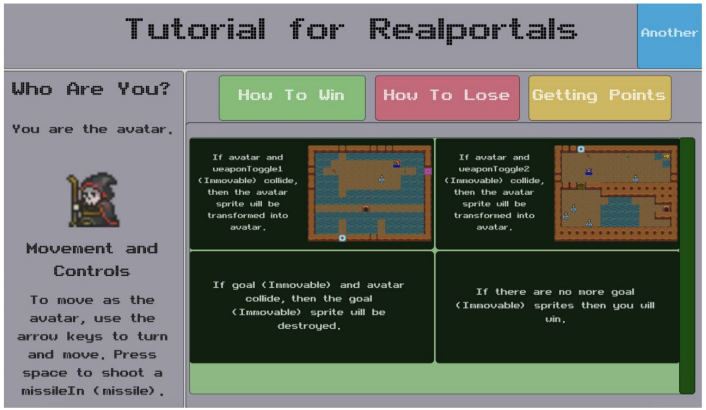
- Constrained Map-Elites
  - Stores 2 populations of samples within the Map-Elites cells;



Previous Work

AtDeLFI

- Showcase critical path mechanics from agent gameplay



arXiv:1807.04375

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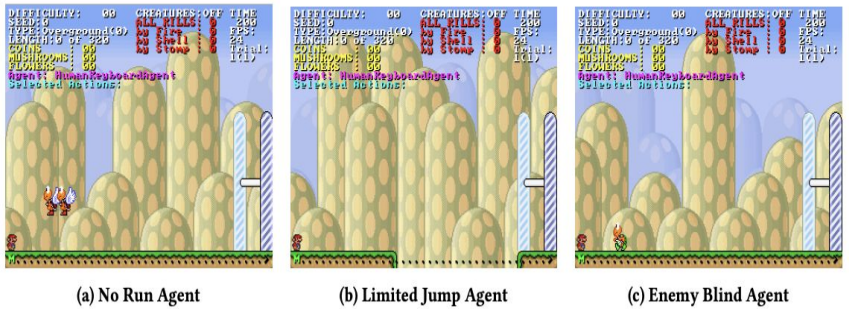
MarioICLD

- Generated Mario levels based on the mechanic(s) performed in the level



(a) No Run Agent (b) Limited Jump Agent (c) Enemy Blind Agent

arXiv:1904.08972

= MechElites

- Generating GVG-AI levels using Constrained MAPElites
- Uses list of mechanics for the game as dimensionality for the map cells

MECHANIC LIST

```
{
    grab key,
    kill enemy
}
```

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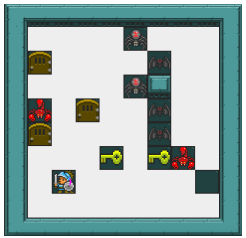
RANDOM LEVELS (x 100)



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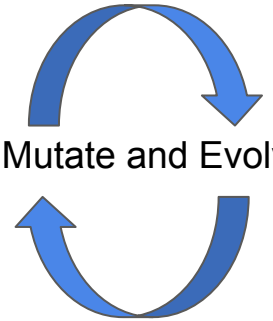

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Methods - Constraints (C)

1. Win condition of the agent (win)
2. Time taken to complete level ($T_{survival}$ vs. T_{ideal})
3. Idle behavior survivability (N)

$$P = \frac{win}{|T_{win} - T_{ideal}|} + \frac{(1 - win) * 0.25}{|T_{survival} - T_{ideal}|}$$

$$E = \begin{cases} 1 & \text{if } \frac{N_{pass}}{N_{total}} \geq 0.5 \\ \frac{N_{pass}}{N_{total}} & \text{otherwise} \end{cases}$$

$$C = P + E$$

Methods - Fitness

- Number of tiles in the level
- Surrounding tile similarity
- Minimalist level and fewer distractions for the player

x

$H(x) = E(\text{all tiles}) = 0.58$
$H(\Delta x) = E(\text{surround tiles}) = 0.35$
$w = 0.5$
fitness = 0.465

Experiment

- Agent: OLETS agent
- 10-20% initially randomized levels each generation
- Ideal time: 70 timesteps
- Total iterations: 500
- Mechanic list for dimensionality extracted from VGDL files

GVG-AI Games

Zelda

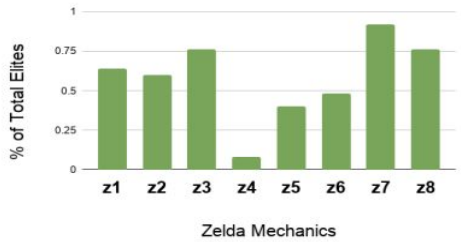
Solarfox

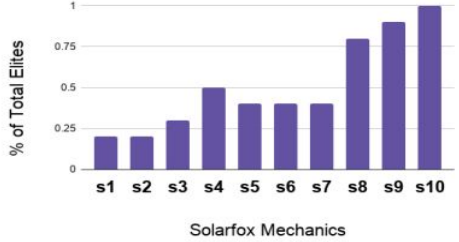
Plants

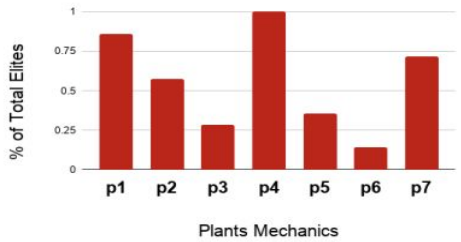
RealPortals

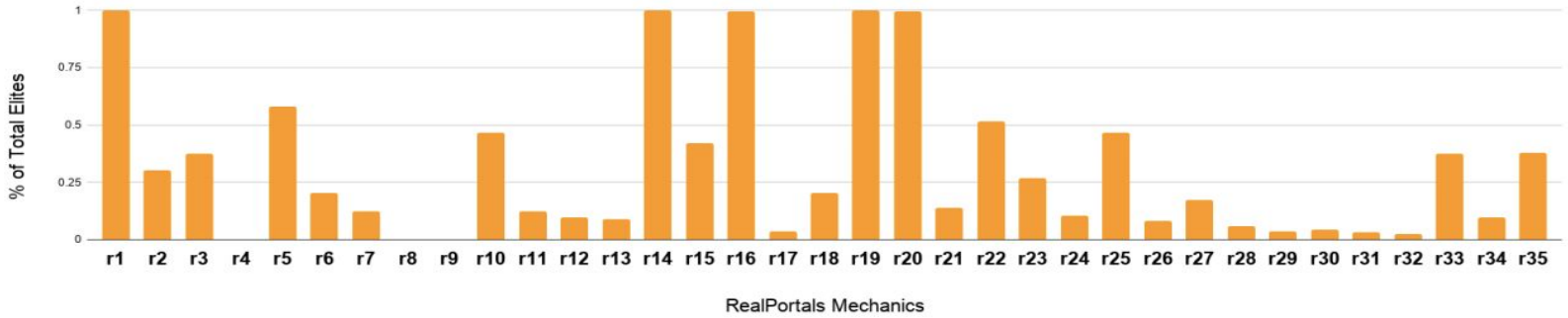
Results

ZELDA - **55 / 256** possible cells filled
SOLARFOX - **52 / 1024** possible cells filled
PLANTS - **31 / 128** possible cells filled
REALPORTALS - **6966 / 34359738368** possible cells filled

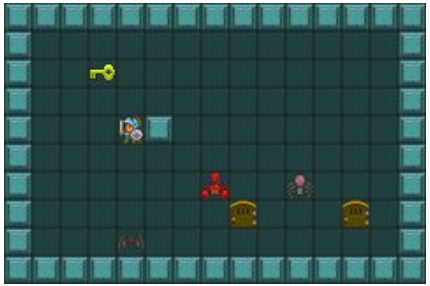








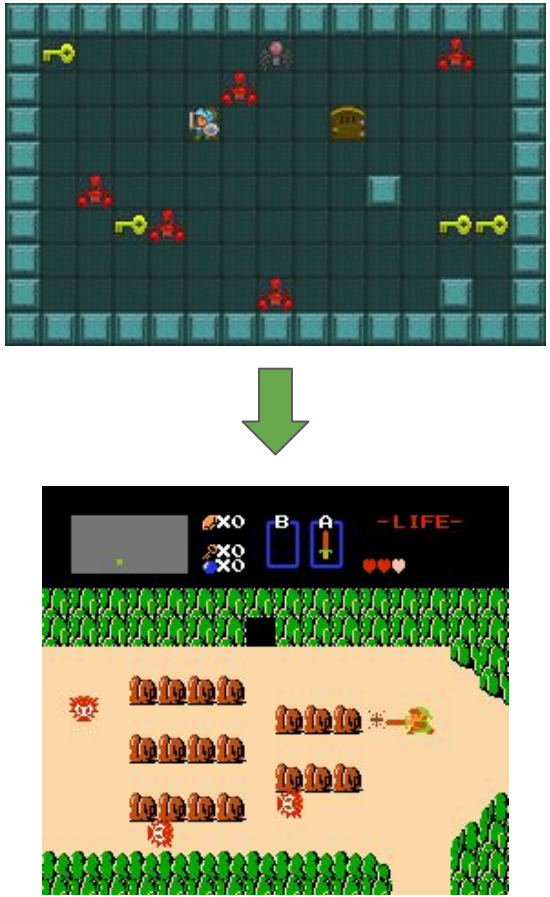
Discussion



- Cell population affected by number of mechanics and complexity of mechanics
- Generated levels have a sense of uniformity with design
- Mechanics may not be *required* or have the *possibility* to be activated
- No patterns present from the original GVG-AI levels

Conclusion

- Proof of concept for developing isolated game mechanic focused levels
- Examine minimal level structure for a mechanic
- Future work to test more games from the GVG-AI framework
- Expand outside the system for games without predefined mechanic space



The Legend of Zelda, Nintendo, 1986

Thanks for watching!

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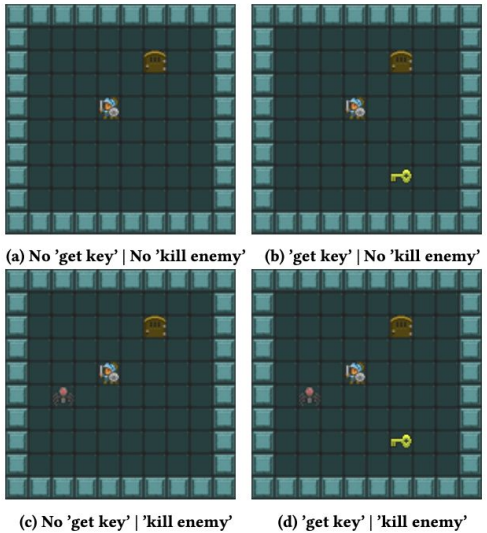
Paper

https://arxiv.org/abs/2002.04733



(a) No 'get key' | No 'kill enemy' (b) 'get key' | No 'kill enemy'

(c) No 'get key' | 'kill enemy' (d) 'get key' | 'kill enemy'