Mario Level Generation From Mechanics Using Scene Stitching

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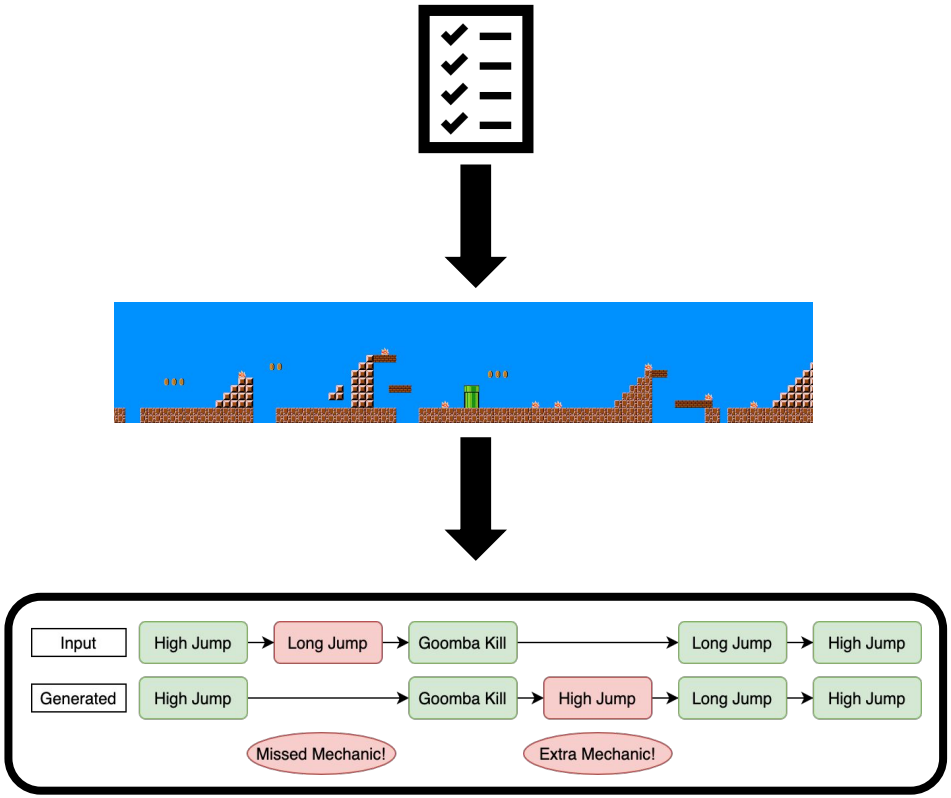
Overview

1. Given: sequence of mechanics*
2. Output a level
3. Same mechanics!



*Things that lead to changes in game state

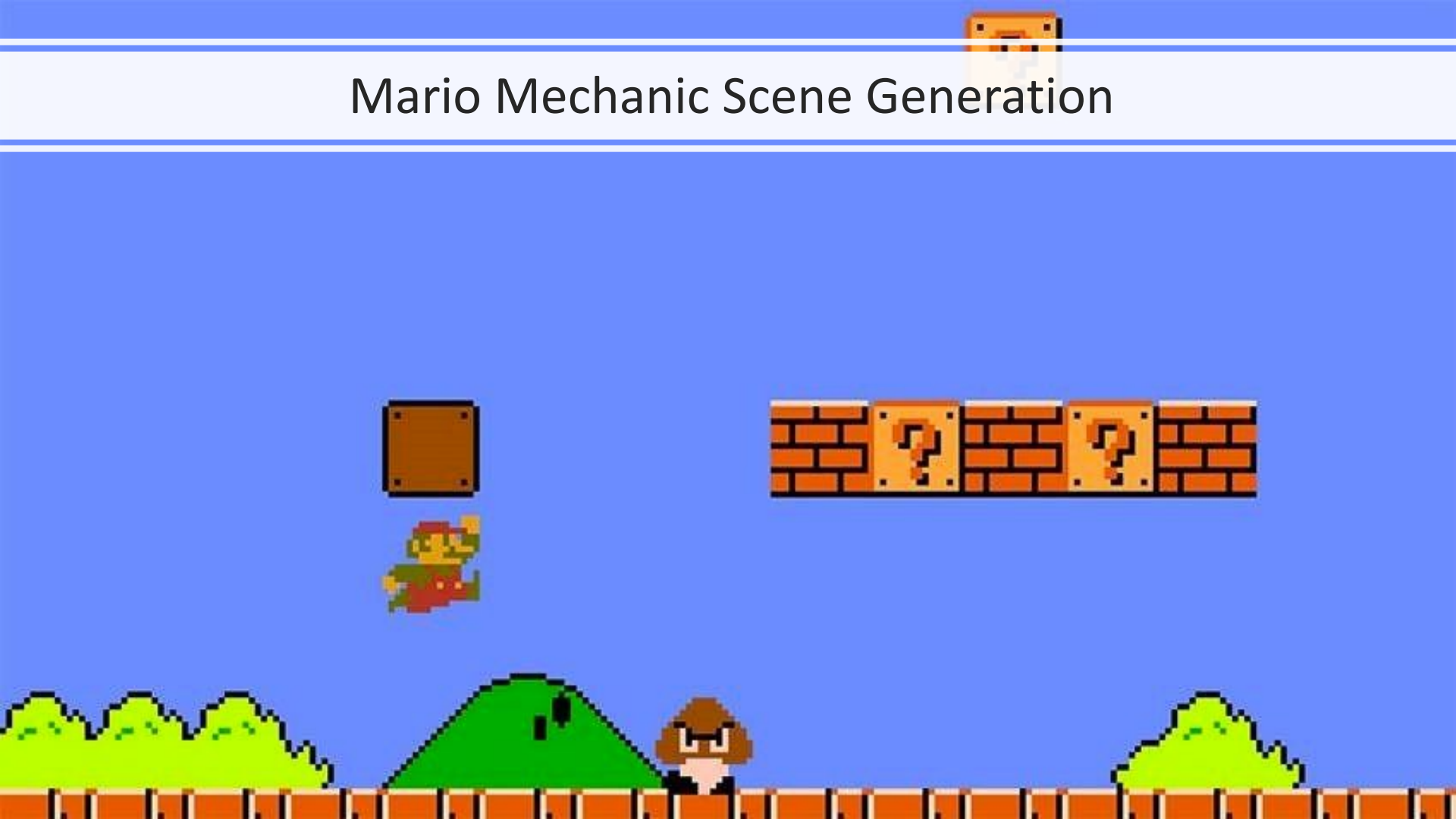
Motivation

- To generate individually personalized levels
- Recreate original levels with different experiences
- Hone skills with environments that highlight skill sets

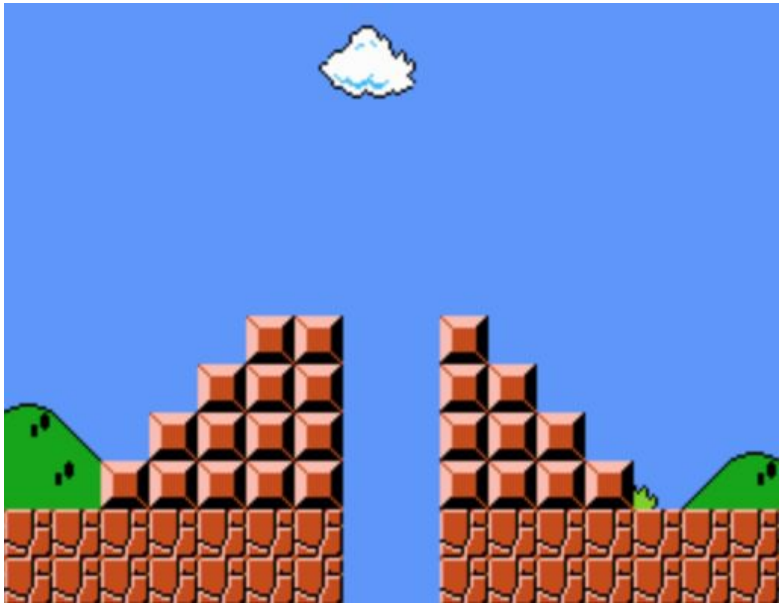
Mario AI Framework

- Nintendo (1985)
- Popular AI environment
- Robin Baumgarten A* Algorithm

Mario Mechanic Scene Generation



Scenes



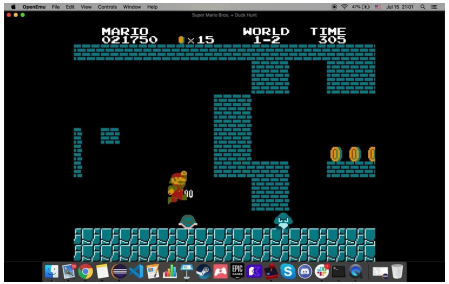
- Self-contained
- Encapsulates an “idea”
- Showcase a set of mechanics
- We chose a 14-tile scene size

Behavioral Characteristics

- A mechanic is anything that leads to change the game state

Jump

Stomp Kill

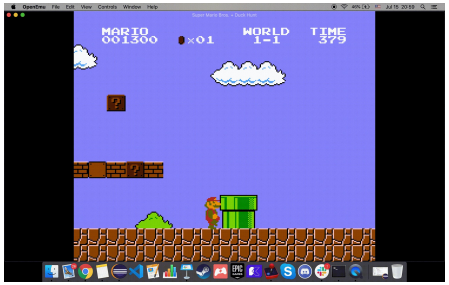


Shell Kill

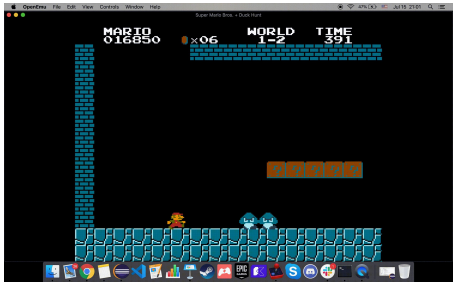
Coin

Behavioral Characteristics

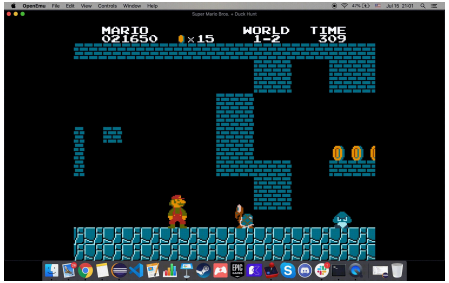
- A mechanic is anything that leads to change the game state



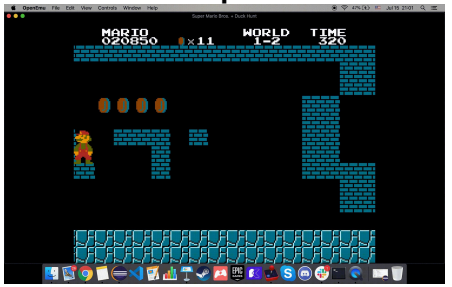
Jump



Stomp Kill



Shell Kill



Coin

Evolution using Constrained MAP-Elites

Dimension	Description
Jump	is 1 if the player jumped in the level and 0 otherwise.
High Jump	is 1 if the player jumped higher than a certain value and 0 otherwise.
Long Jump	is 1 if the player's horizontal traversed distance after landing is larger than a certain value and 0 otherwise.
Stomp	is 1 if the player stomped on an enemy and 0 otherwise.
Shell Kill	is 1 if the player killed an enemy using a koopa shell and 0 otherwise.
Fall Kill	is 1 if an enemy dies because of falling out of the scene and 0 otherwise.
Mushroom	is 1 if the player collected a mushroom during the scene and 0 otherwise.
Coin	is 1 if the player collected a coin during the scene and 0 otherwise.

https://arxiv.org/abs/1904.08972

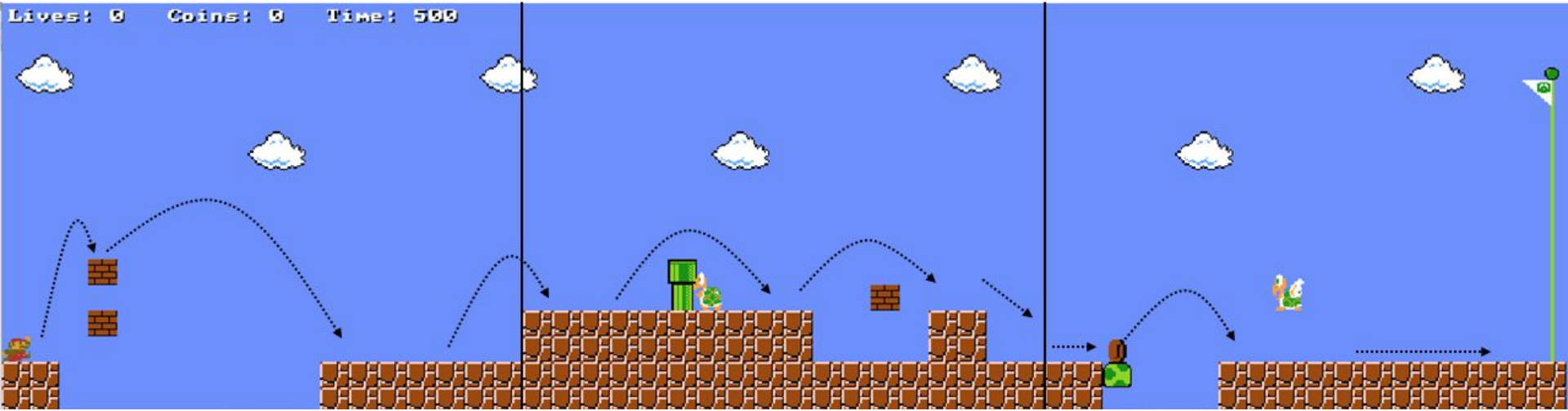
Targeted Mechanics

Name	Description	Frequency
Low Jump	Mario performs a small hop	25.9%
High Jump	Mario jumps very high	39.44%
Short Jump	Mario jumps and hardly moves forward	28.33%
Long Jump	Mario jumps and moves forward a large amount	19.75%
Stomp Kill	Mario kills an enemy by jumping on it	78.77%
Shell Kill	An enemy is killed by a koopa shell	37.85%
Fall Kill	An enemy falls off the game screen	50%
Mode	Mario changes his mode (small, big, and fire)	22.77%
Coin	Mario collects a coin	50.5%
Brick Block	Mario bumps into a brick block	41.1%
? Block	Mario bumps into a ? mark block	59.79%

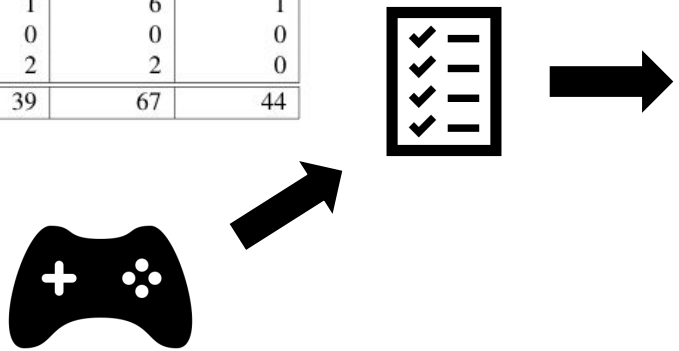
Mario game mechanics and the percentage of evolved scenes that contain them.

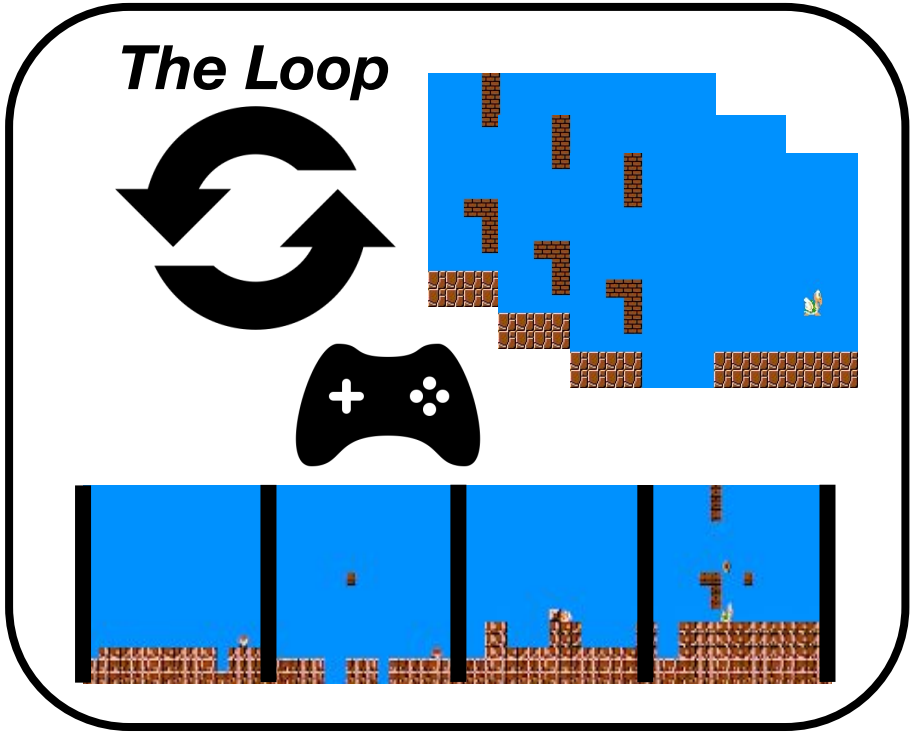
Stitching Scenes

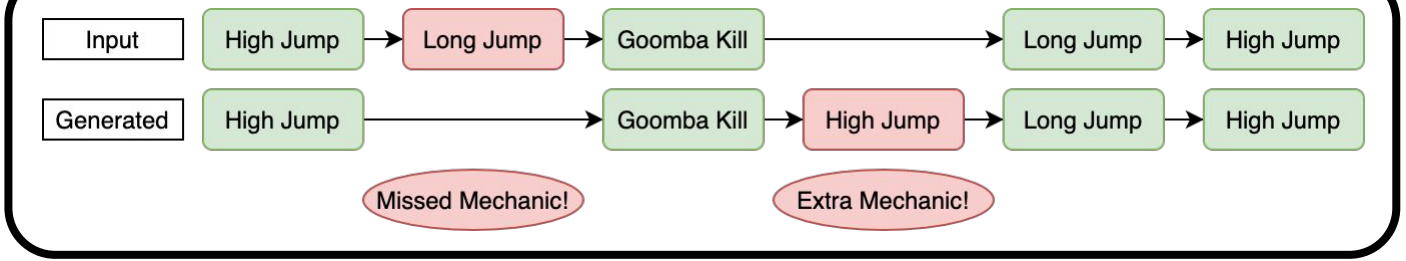
- Create bigger levels
- New inter-scene mechanics



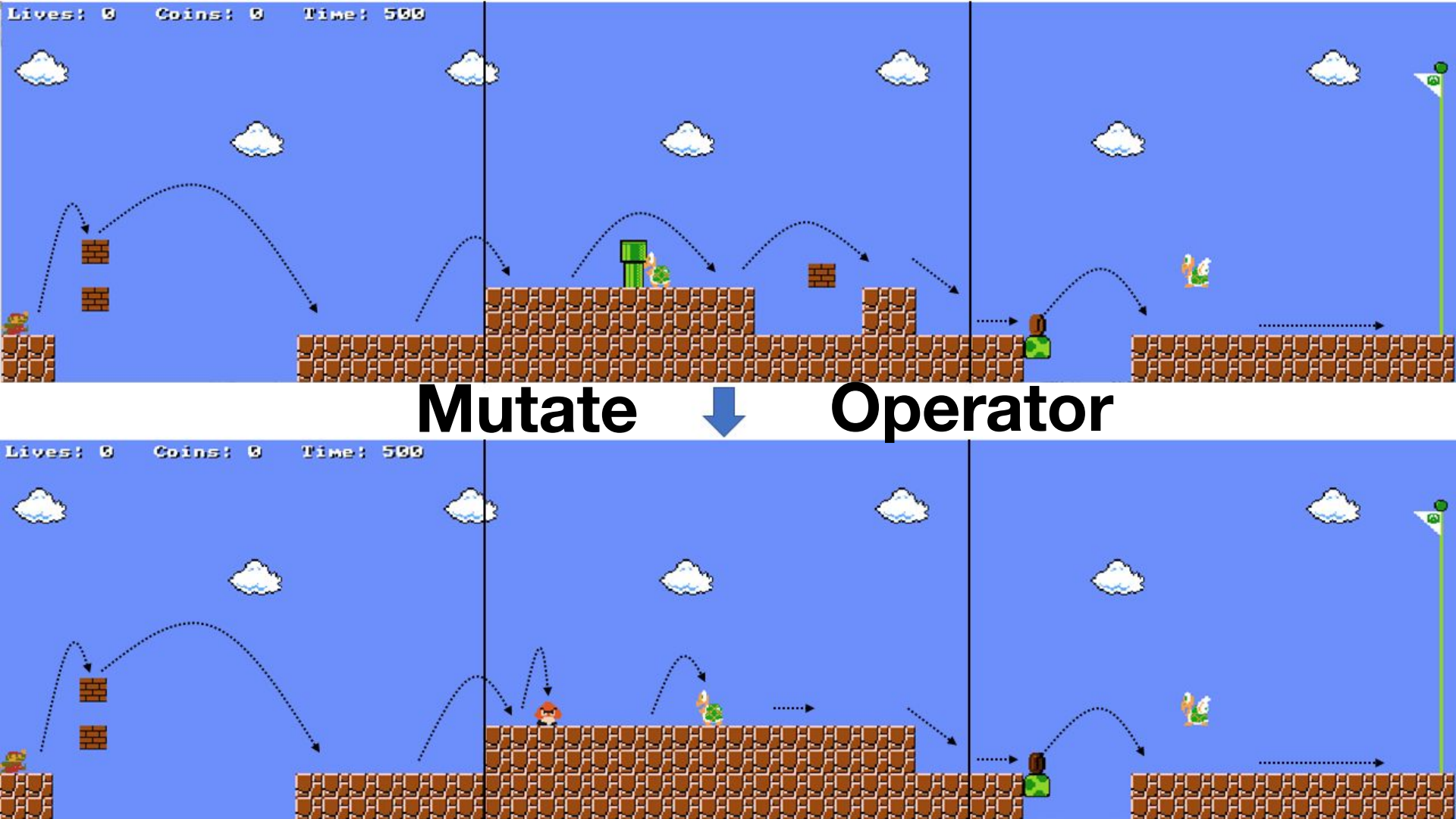
Mechanic	Level 1-1	Level 4-2	Level 6-1
Low Jump	14	20	18
High Jump	4	9	4
Short Jump	6	16	14
Long Jump	11	12	7
Stomp Kill	1	2	0
Shell Kill	0	0	0
Fall Kill	0	0	0
Mode	0	0	0
Coin	1	6	1
Brick Block	0	0	0
? Block	2	2	0
Total	39	67	44

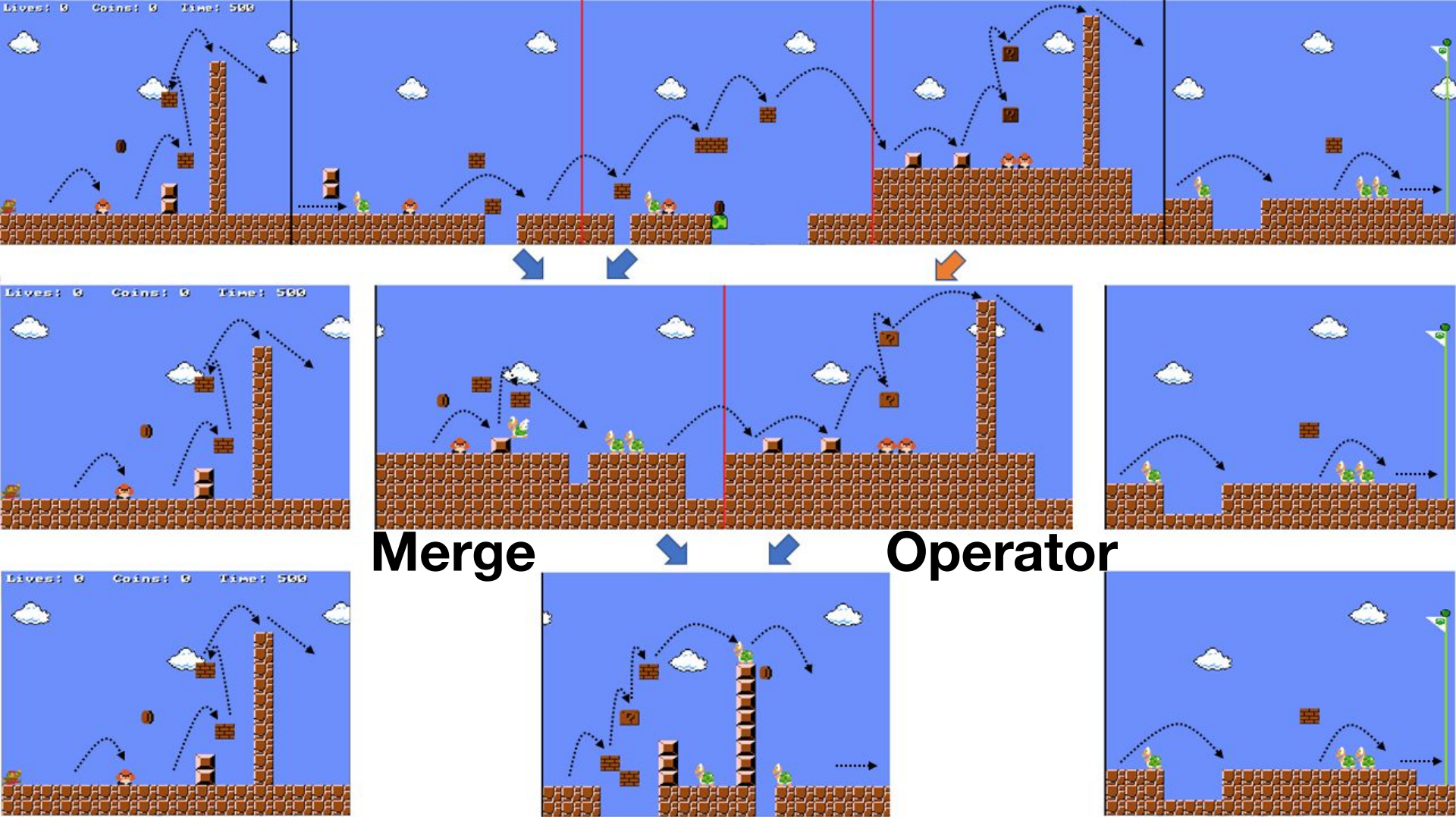


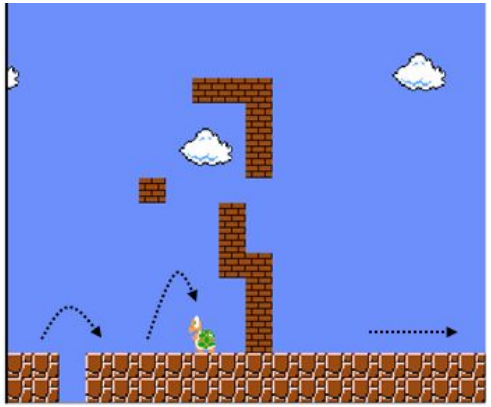


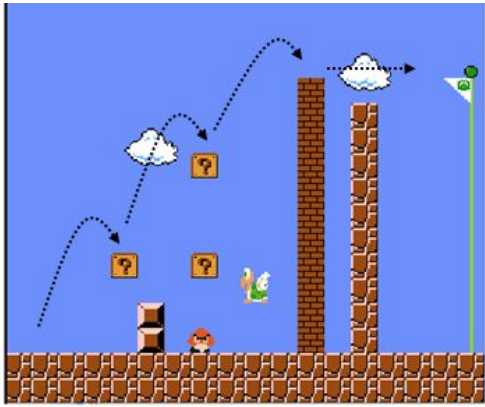


@bumblebor

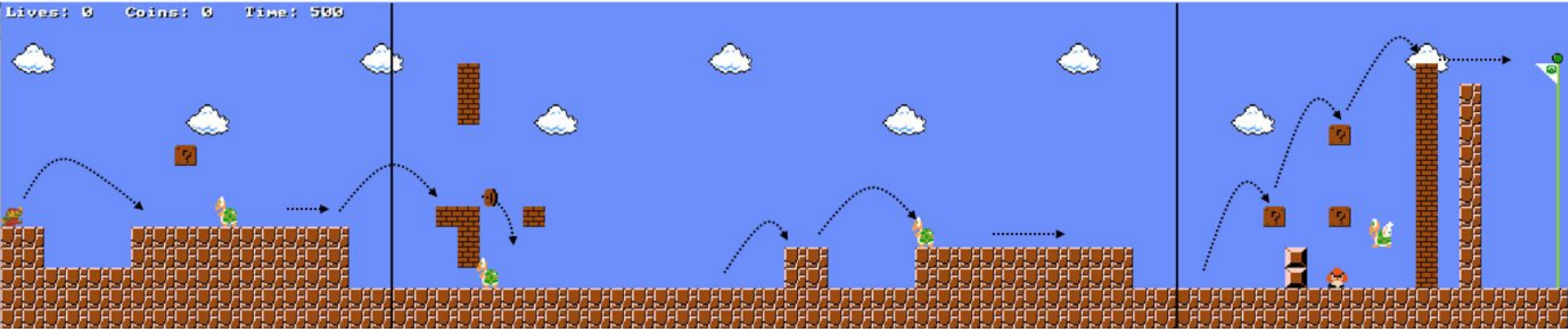

Lives: 0 Coins: 0 Time: 500
Mutate
Operator
Lives: 0 Coins: 0 Time: 500


Lives: 0 Coins: 0 Time: 500
Lives: 0 Coins: 0 Time: 500
Merge
Operator
Lives: 0 Coins: 0 Time: 500





Divide Operator



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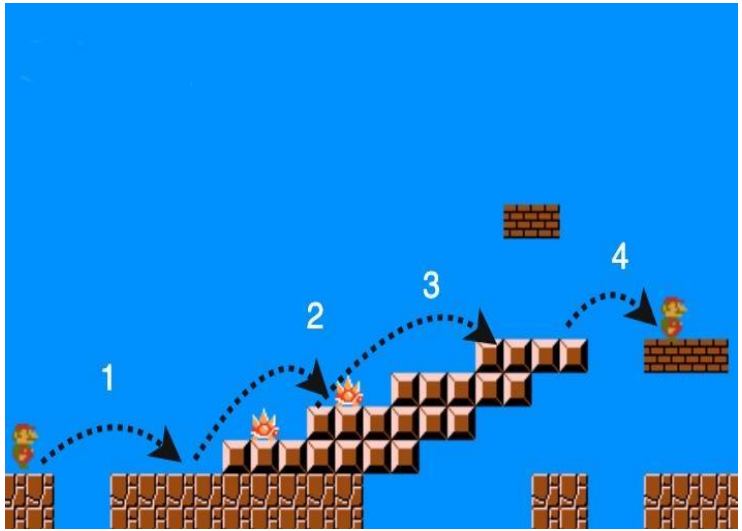
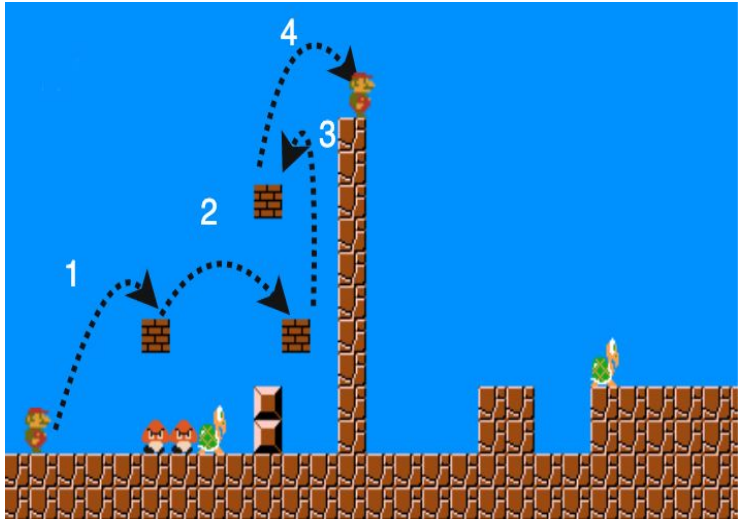
Resulting Artifacts



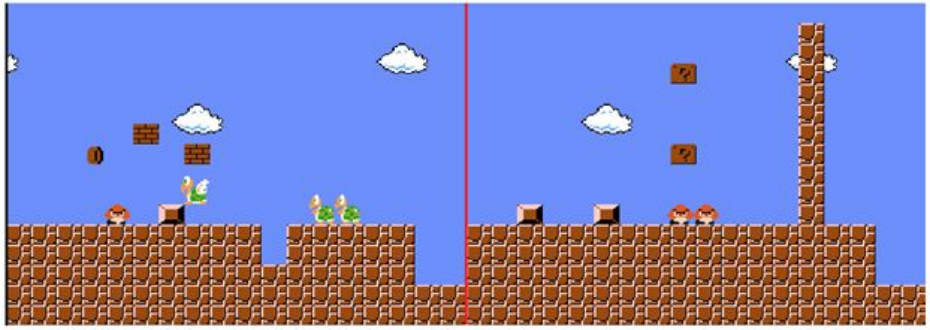
Original

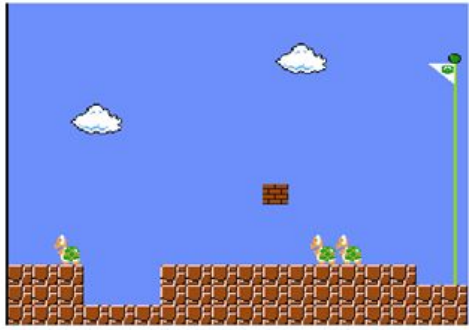


Evolved

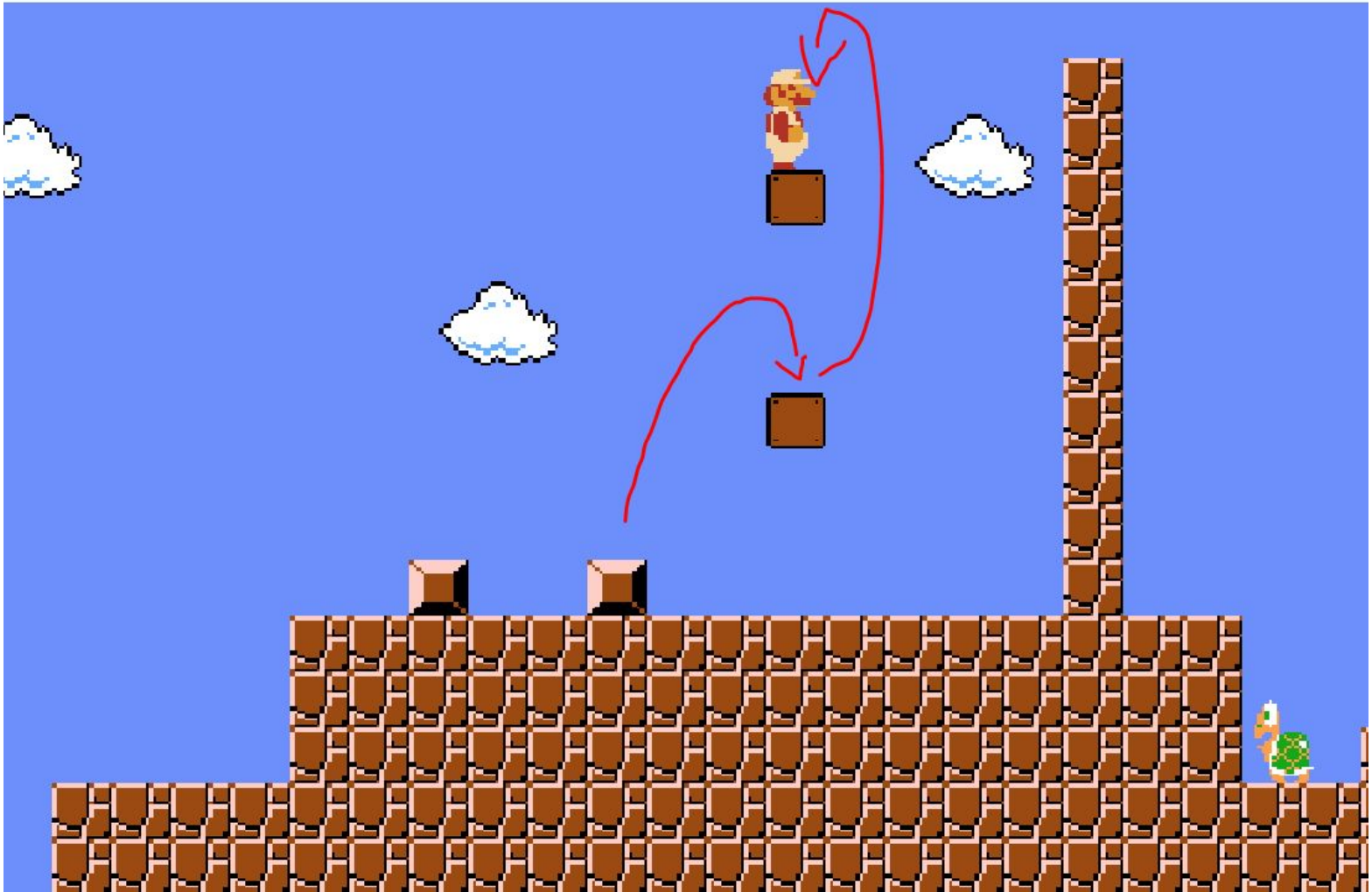

Lives: 0 Coins: 0 Time: 500


Lives: 0 Coins: 0 Time: 500

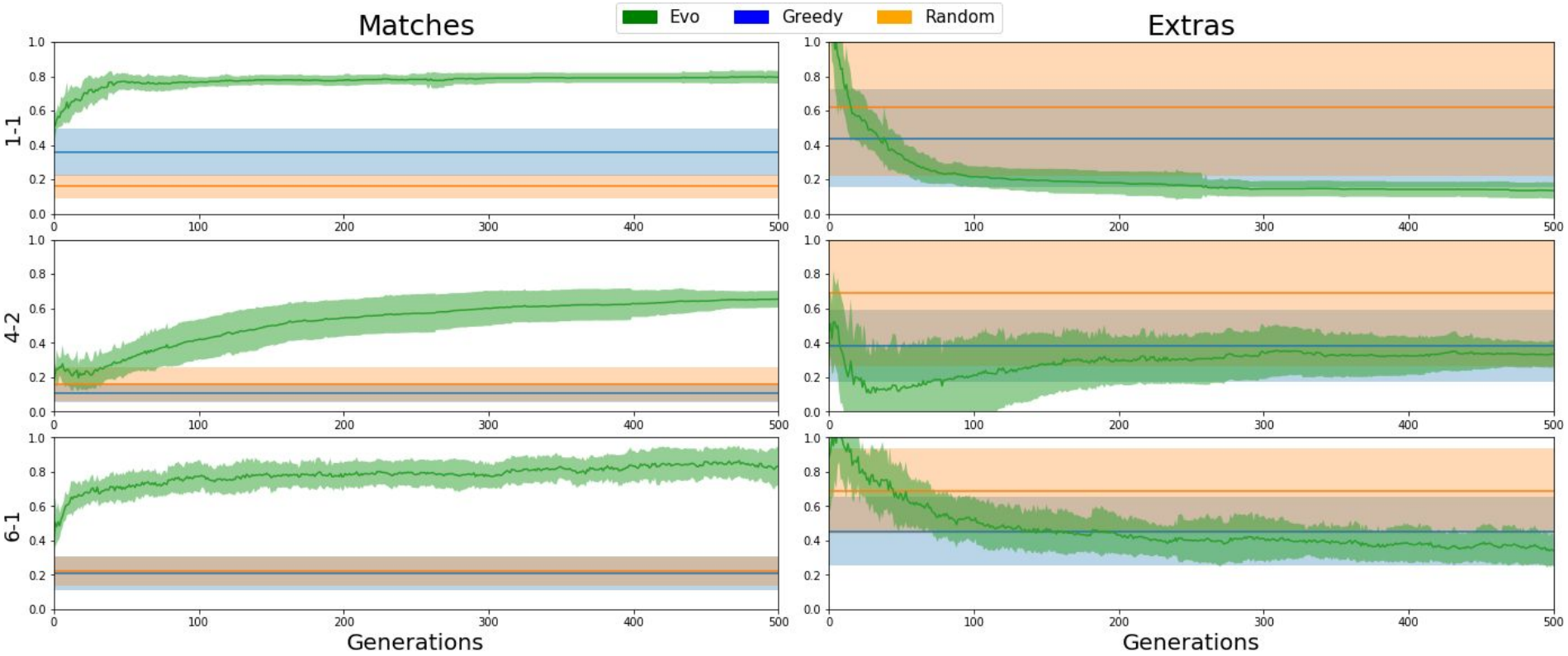





Lives: 0 Coins: 0 Time: 500



Results


Evo
Greedy
Random
Matches
Extras
1-1
4-2
6-1
Generations
Generations

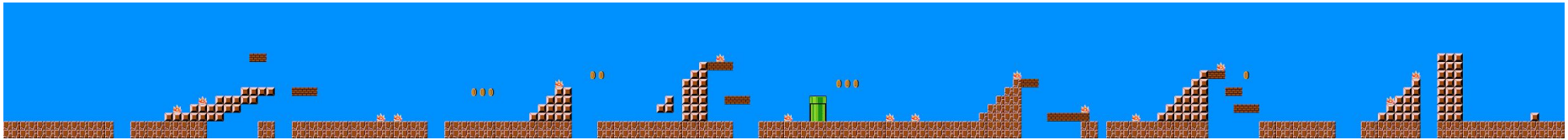
Results

Experiment	Playability	Inter-TPKLDiv	Intra-TPKLDiv
Original Levels	52%	0.715 ± 0.410	-
Random Levels 1-1	10.75%	0.697 ± 0.265	2.941 ± 1.005
Greedy World 1-1	28.5%	0.675 ± 0.228	2.636 ± 0.795
Evolution World 1-1	100%	0.269 ± 0.127	1.601 ± 0.573
Random Levels 4-2	10.75%	0.697 ± 0.265	2.941 ± 1.005
Greedy World 4-2	26.25%	0.648 ± 0.181	3.329 ± 0.647
Evolution World 4-2	99.5%	0.264 ± 0.094	1.997 ± 0.466
Random Levels 6-1	10.75%	0.697 ± 0.265	2.941 ± 1.005
Greedy World 6-1	25%	0.648 ± 0.172	2.601 ± 0.577
Evolution World 6-1	87.25%	0.348 ± 0.117	1.505 ± 0.404

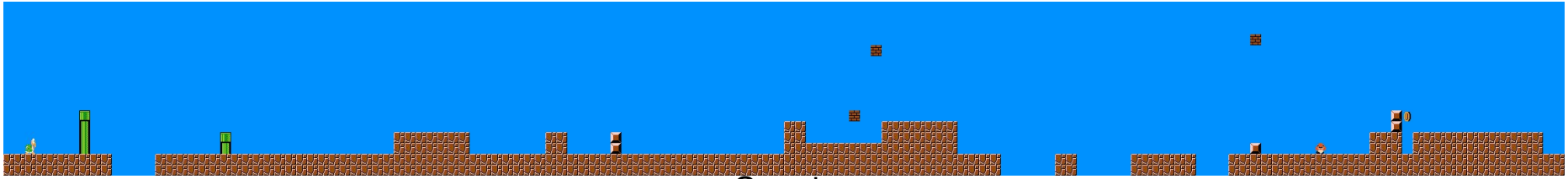
- Extremely Playable!
- Not as diverse (relatively)

- Matching pressure minimizes diversity
- Playability hurts diversity

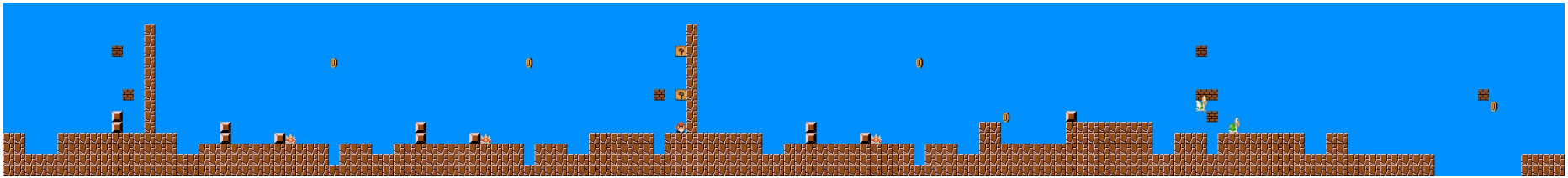
World 6-1



Original



Greedy



Evolved

Future Work

- Tutorial generation
  - Levels that teach specific sequences
  - Sequences with varying complexity/difficulty
- Repeat old levels but with structural differences
- Use agent personas for different input playtraces