Desire Path-Inspired Procedural Placement of Coins in a Platformer Game

Anurag Sarkar, Varun Sriram, Riddhi Padte, Jeffrey Cao, Seth Cooper

College of Computer and Information Science

Northeastern University

Motivation

https://www.gamasutra.com/view/news/243310/6_musts_for_a_perfect_platformer_from_the_YookaLaylee_team.php

Motivation

- Collectibles such as coins, bonuses, power-ups feature in many games and genres

https://www.gamasutra.com/view/news/243310/6_musts_for_a_perfect_platformer_from_the_YookaLaylee_team.php

Motivation

- Collectibles such as coins, bonuses, power-ups feature in many games and genres
- Collecting them is often a secondary objective either related or unrelated to a primary objective

https://www.gamasutra.com/view/news/243310/6_musts_for_a_perfect_platformer_from_the_YookaLaylee_team.php

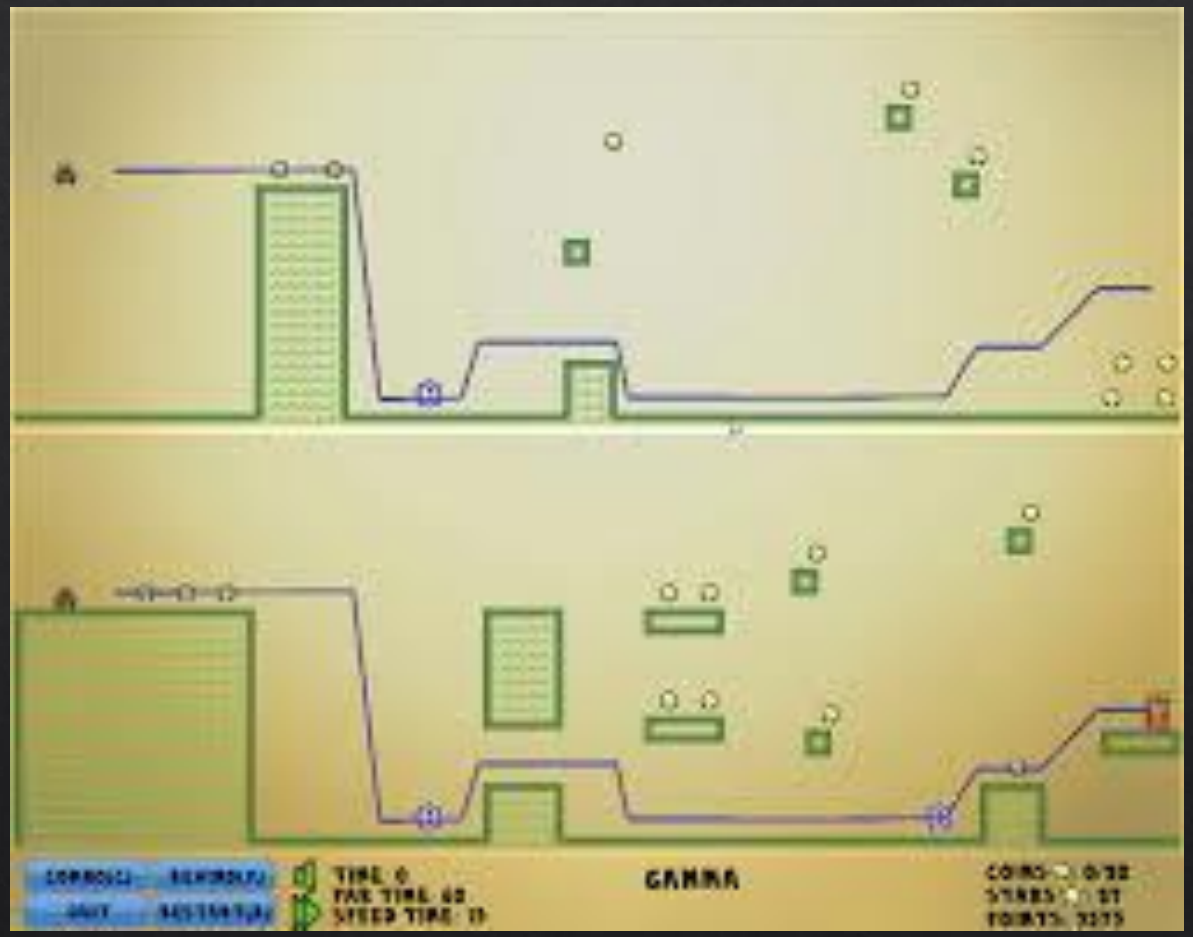
Motivation

- Collectibles such as coins, bonuses, power-ups feature in many games and genres
- Collecting them is often a secondary objective either related or unrelated to a primary objective
- Automating placement of collectibles could save the designer's time by helping them focus on the primary goals of the level

https://www.gamasutra.com/view/news/243310/6_musts_for_a_perfect_platformer_from_the_YookaLaylee_team.php

Automated Placement

- Items may decrease engagement if placed in a way that does not serve the primary objective of the levels

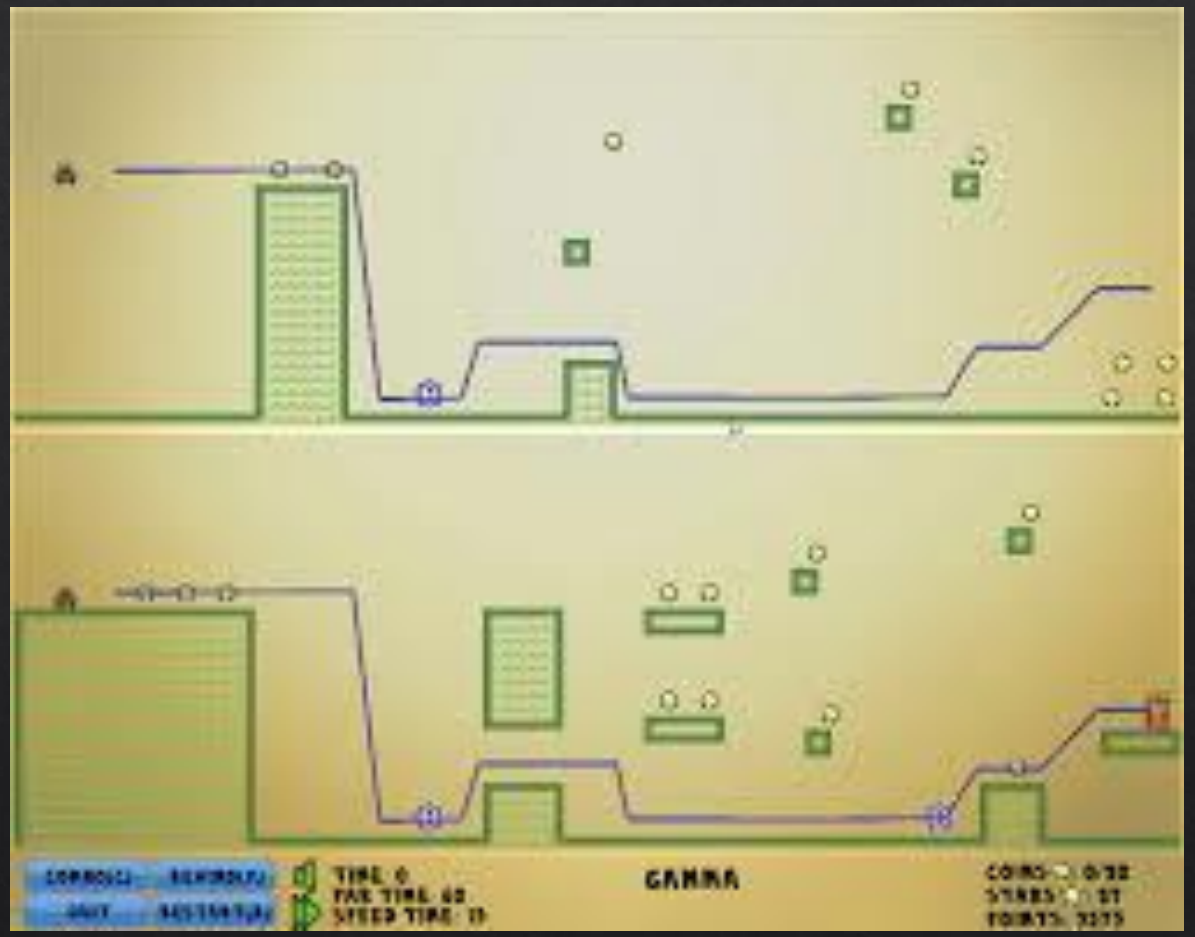


Andersen et al., 2011

Automated Placement

- Items may decrease engagement if placed in a way that does not serve the primary objective of the levels

- Placement should consider the level's primary objective and how the player achieves that goal



Andersen et al., 2011

Desire Paths

Desire Paths

- Paths created by footfall rather than construction

Desire Paths

- Paths created by footfall rather than construction
- Represent a shortcut or less circuitous route than a constructed walkway

Desire Paths

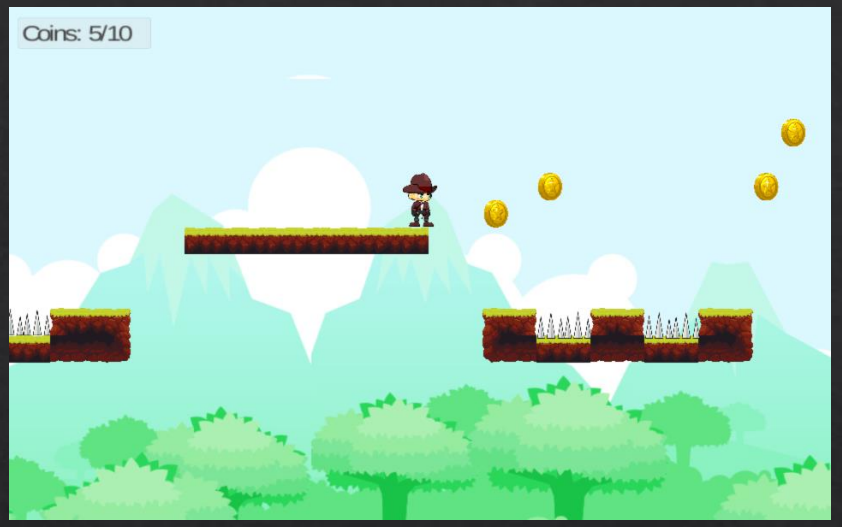
- Paths created by footfall rather than construction
- Represent a shortcut or less circuitous route than a constructed walkway
- We use *desire paths* to refer to simple paths through levels that players are likely to traverse

Desire Paths

- Paths created by footfall rather than construction
- Represent a shortcut or less circuitous route than a constructed walkway
- We use *desire paths* to refer to simple paths through levels that players are likely to traverse
- Placing collectibles along these paths may help placement

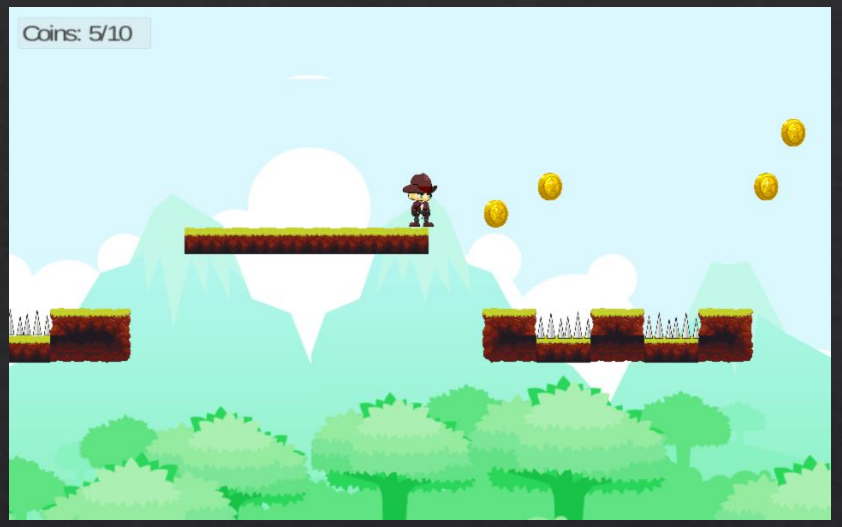
Iowa James: Treasure Hunter

- Platformer game consisting of 14 levels developed in Unity



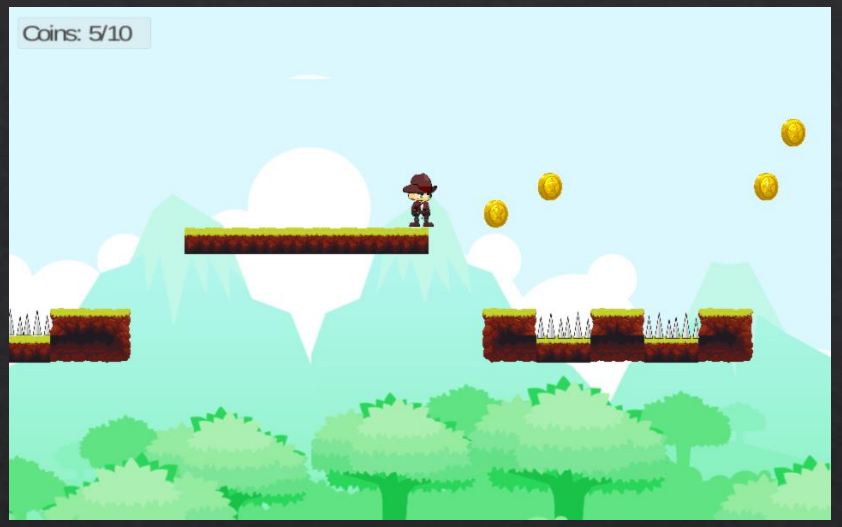
Iowa James: Treasure Hunter

- Platformer game consisting of 14 levels developed in Unity
- Goal is to reach treasure chest at the end of each level



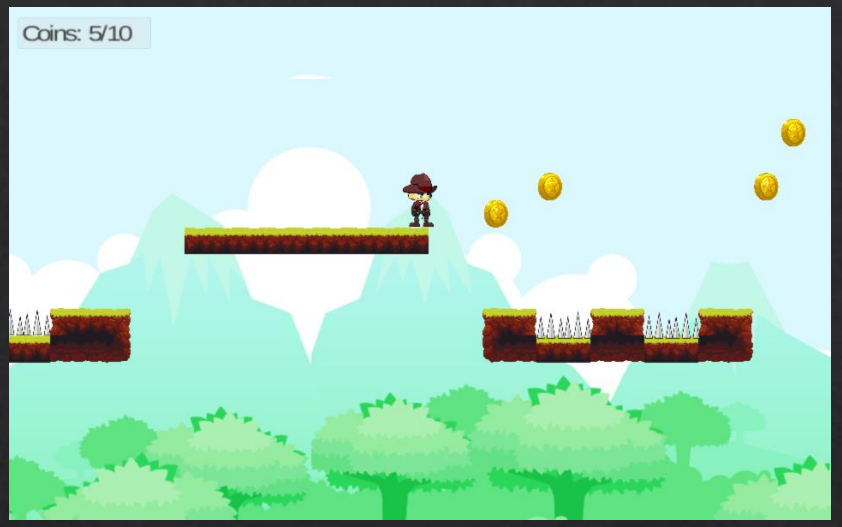
Iowa James: Treasure Hunter

- Platformer game consisting of 14 levels developed in Unity
- Goal is to reach treasure chest at the end of each level
- Several hazards that can kill the player



Iowa James: Treasure Hunter

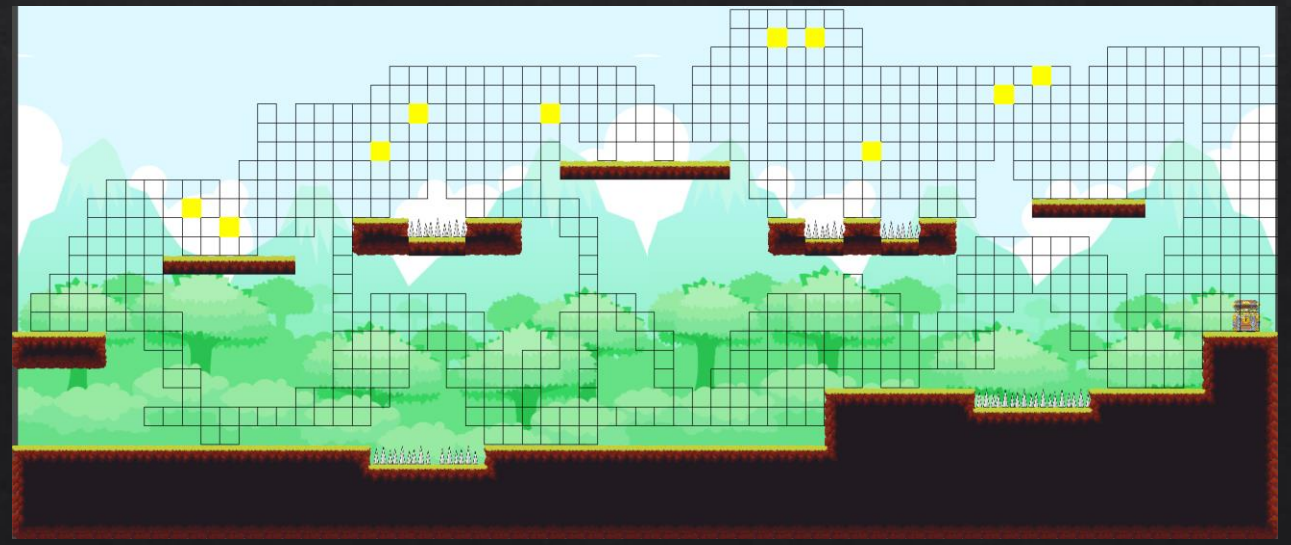
- Platformer game consisting of 14 levels developed in Unity
- Goal is to reach treasure chest at the end of each level
- Several hazards that can kill the player
- Each level has 10 collectible coins



Placement Heuristics

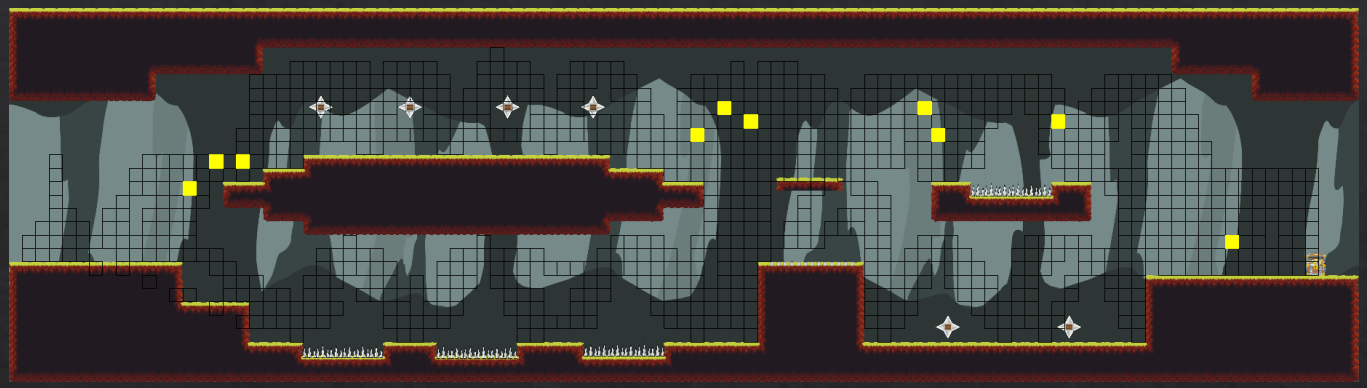
Placement Heuristics

- *Main Heuristic*
  - Coins should be on a single path



Placement Heuristics

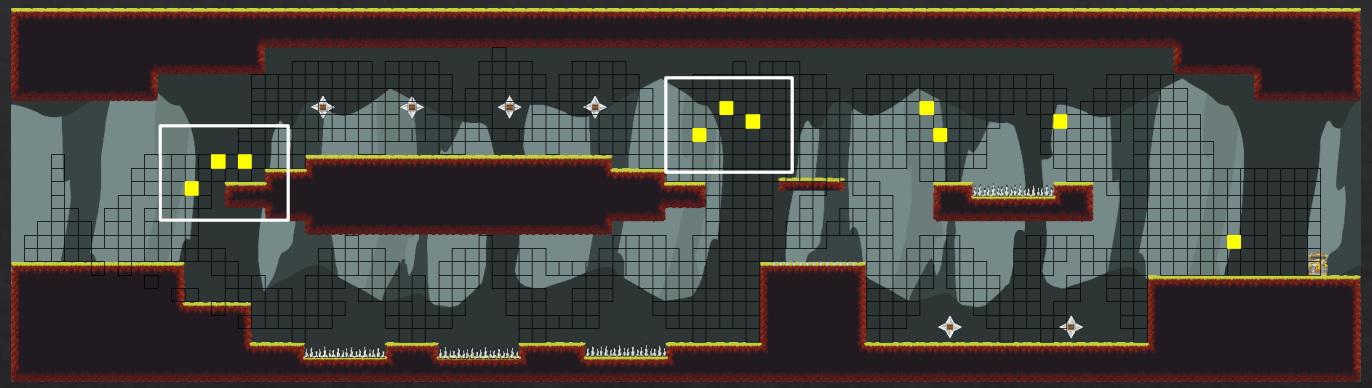
- *Main Heuristic*
  - Coins should be on a single path



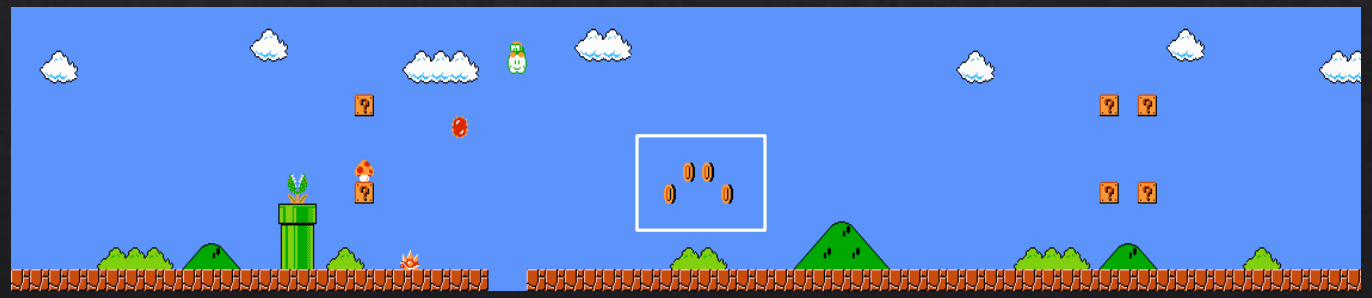
- *Additional Heuristics*
  - Coins should be well distributed throughout the level

Placement Heuristics

- *Main Heuristic*
  - Coins should be on a single path

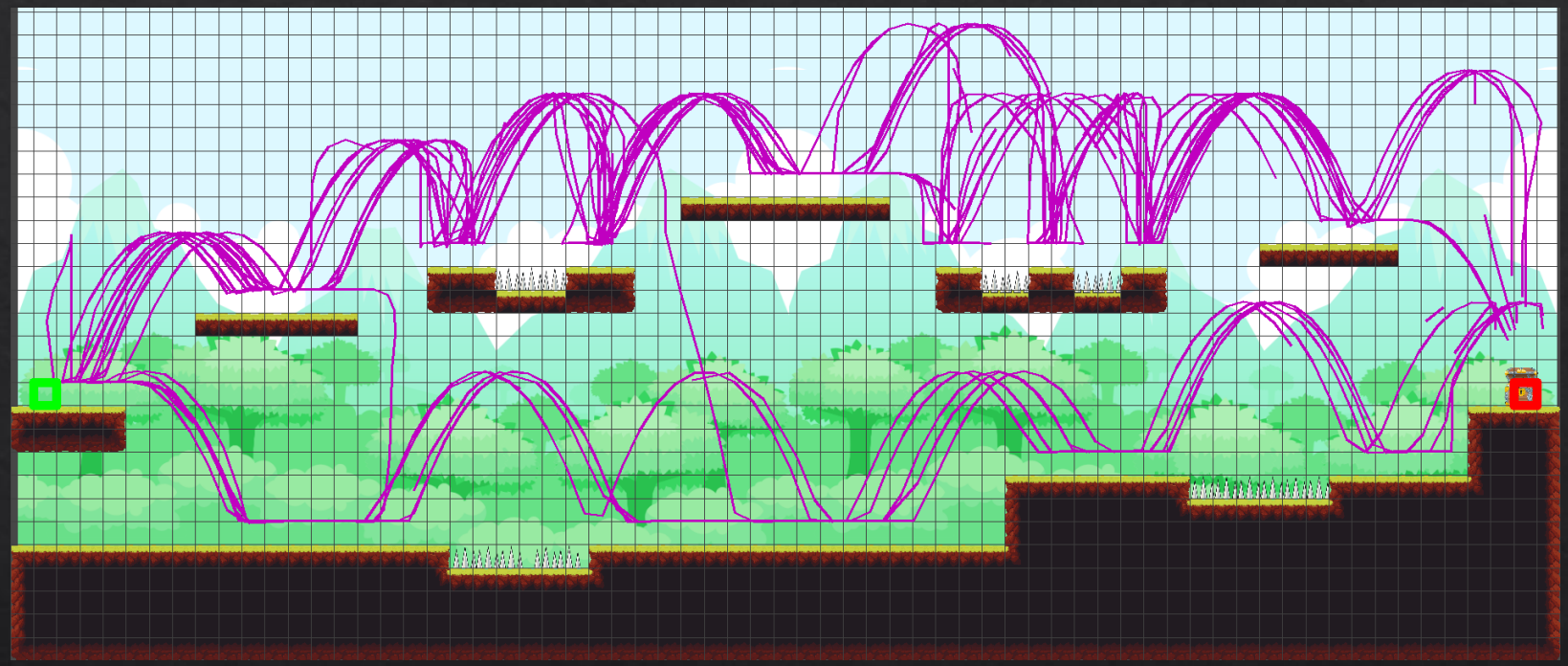


- *Additional Heuristics*
  - Coins should be well distributed throughout the level
  - Coins should be clustered near curves and arcs



Path-Based Placement Algorithm

- *Inputs*
  - Number of coins to place
  - Grid cell definition
  - Starting and ending locations
  - Player trajectories of players who won the level



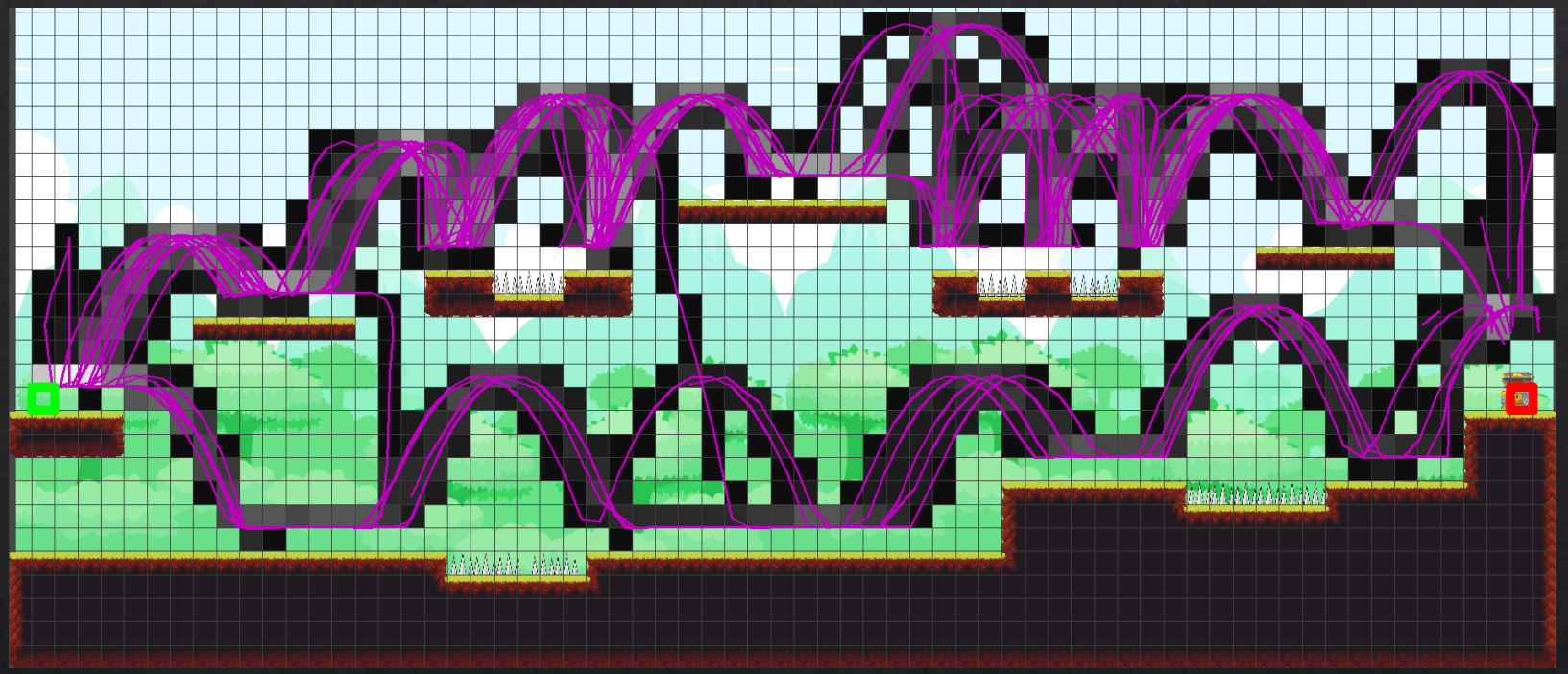
Path-Based Placement Algorithm

- *Step 1*

For each grid cell $c = (x_c, y_c)$, count proportion w_c of winning trajectories that pass through that cell.

$w_c = 0$ → no winning trajectories went through

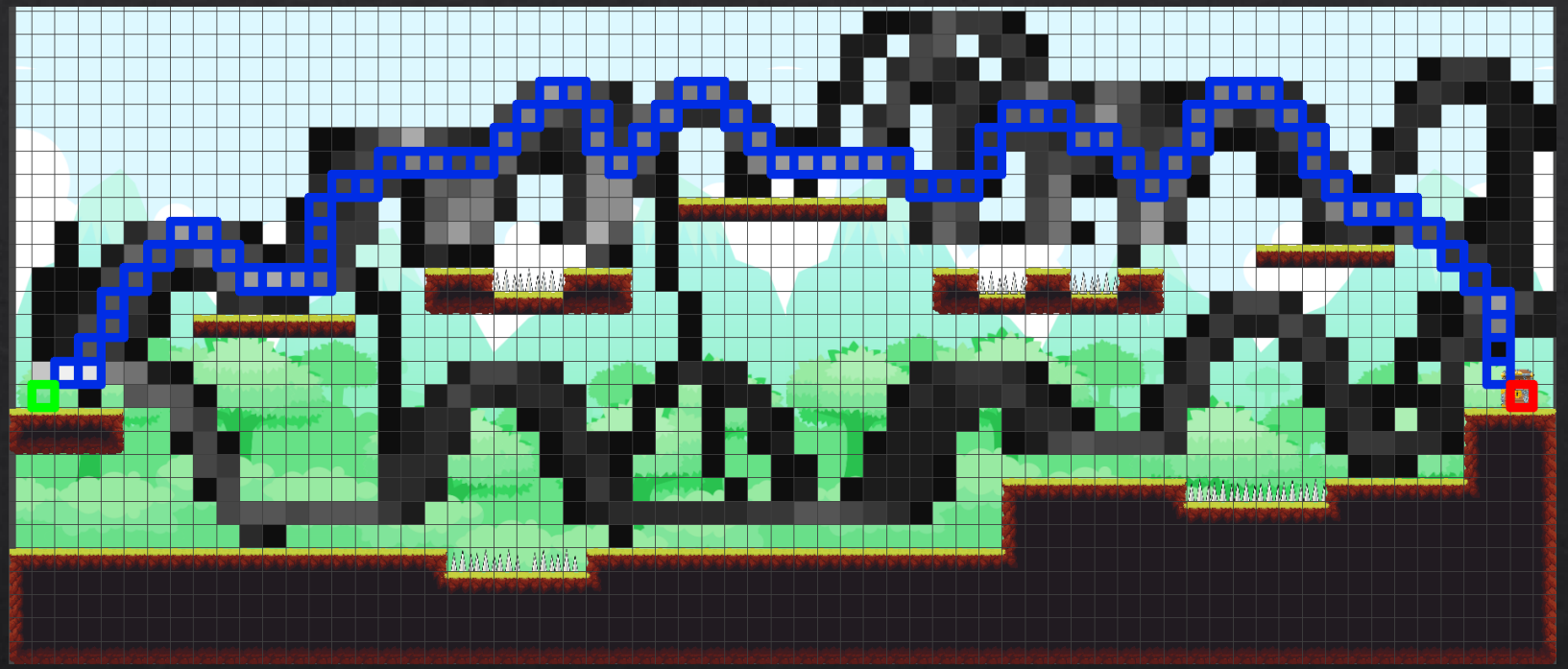
$w_c = 1$ → all winning trajectories went through



Path-Based Placement Algorithm

- *Step 2*

Find the lowest cost A* path through the grid from start cell to end cell.

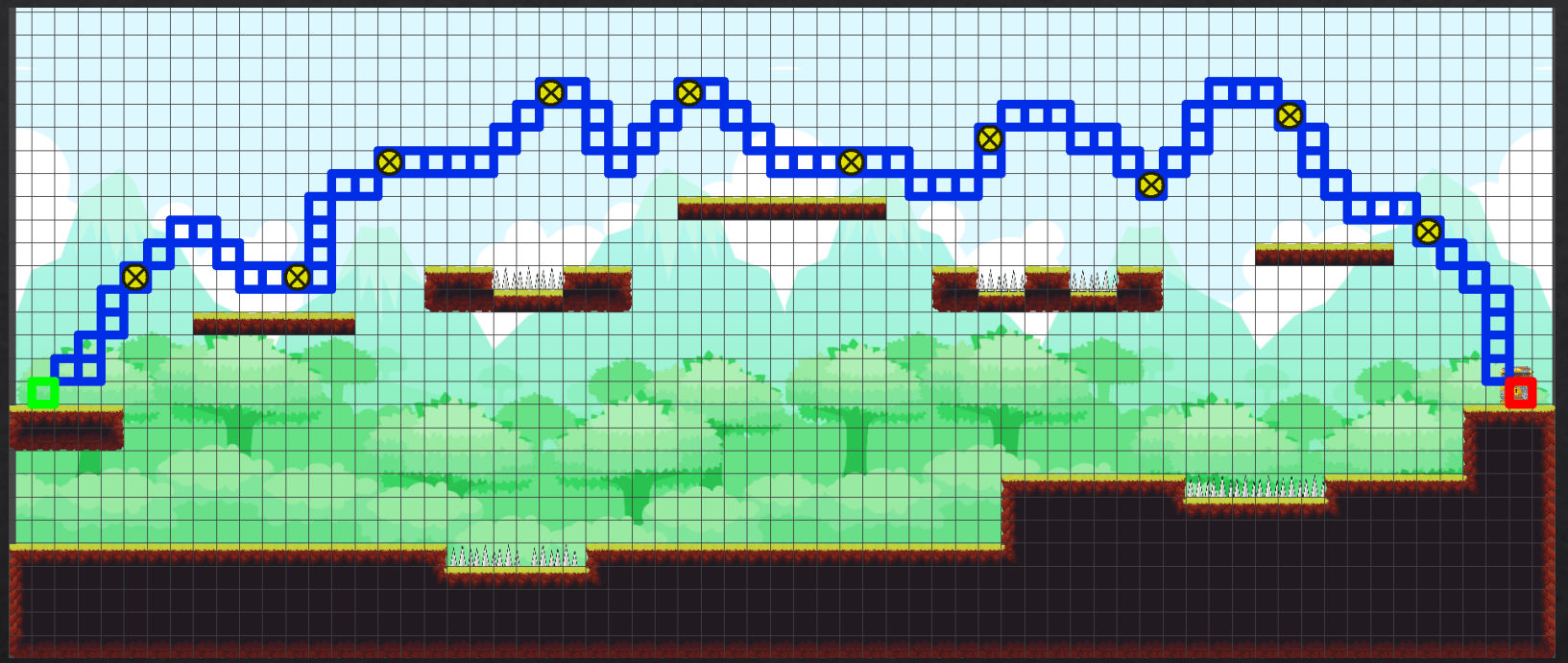


Cost to move from cell s to t : $\dfrac{|t - s|}{\max(w_t, e)^2}$

Path-Based Placement Algorithm

- *Step 3*

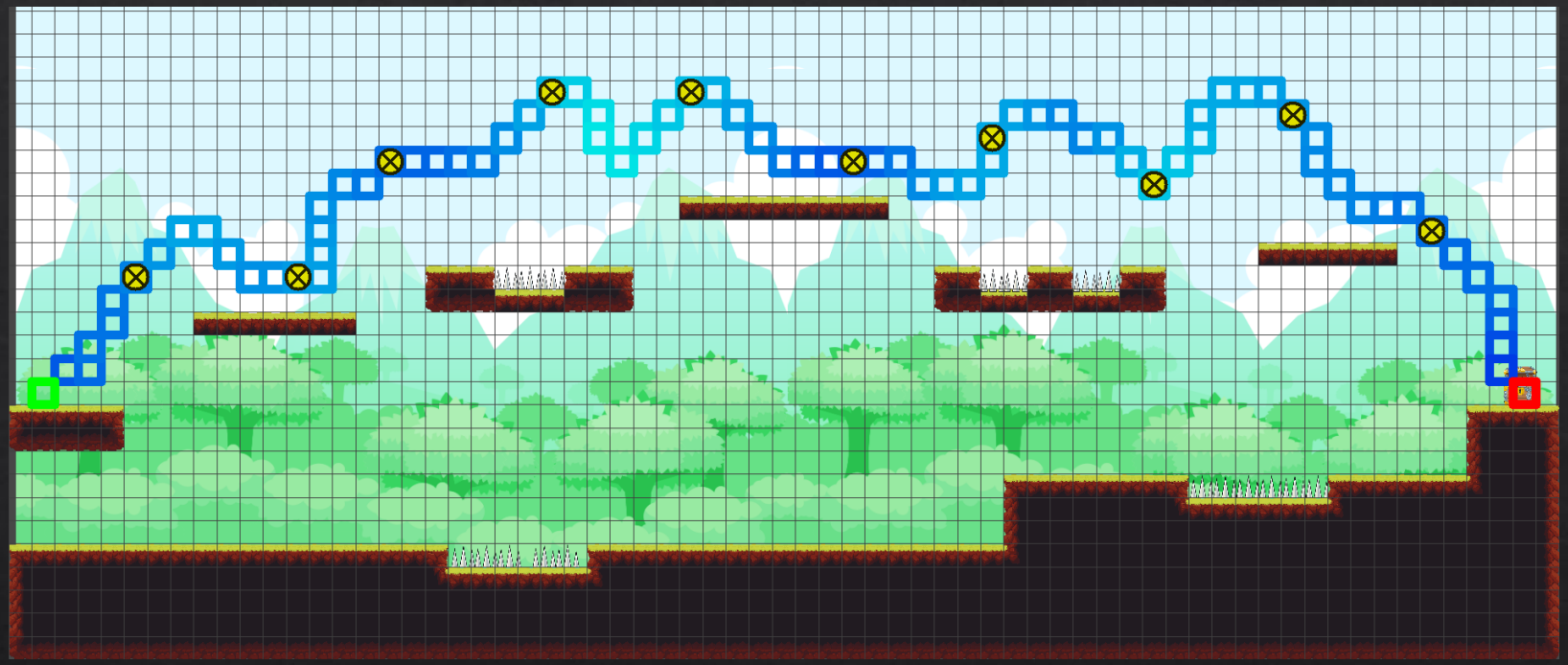
Place the required number of coins evenly spaced along the path



Path-Based Placement Algorithm

- *Step 4*

For each grid cell p_i along the path, compute a priority value r_i using an estimate of the local deviation from a straight line



$$r_i = |p_i - 0.5 * (p_{i-1} + p_{i+1})|^2 + |p_i - 0.5 * (p_{i-2} + p_{i+2})|$$

Path-Based Placement Algorithm

- *Step 5*

Given a coin at p_i

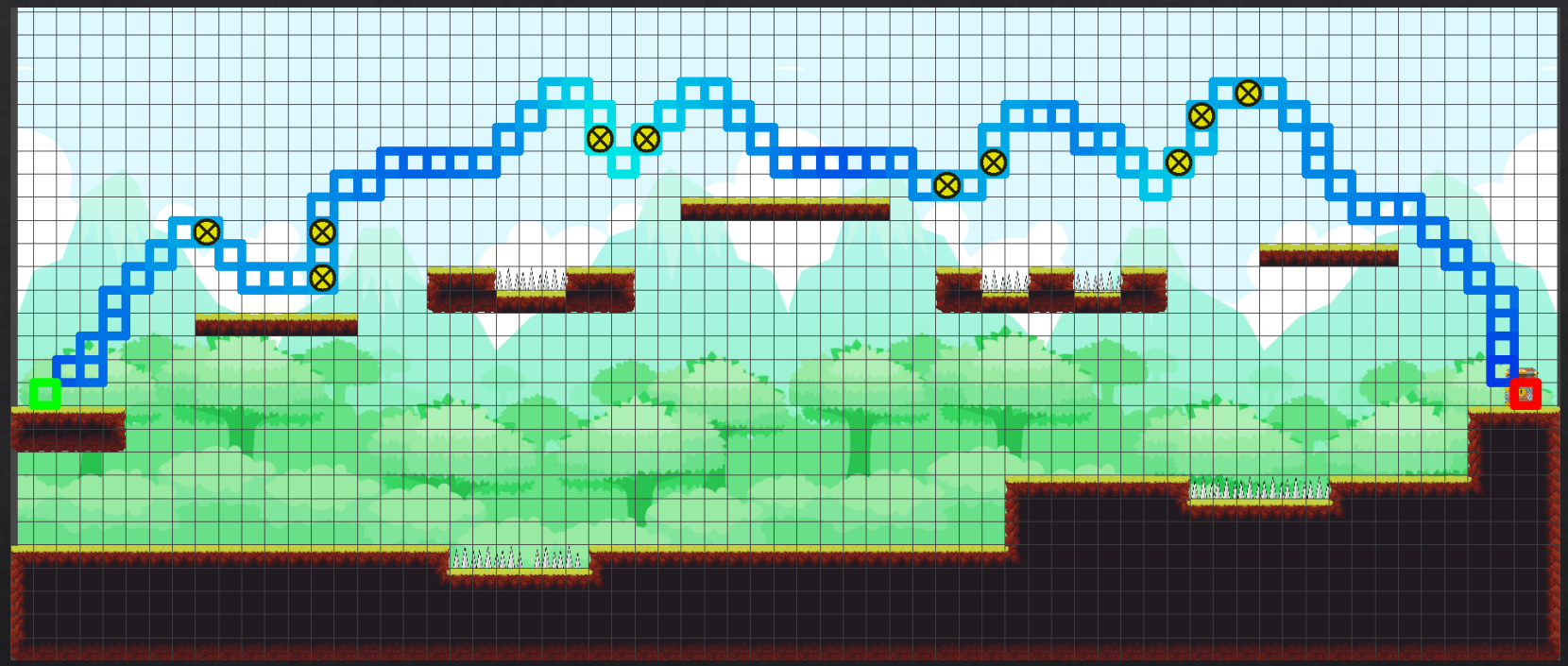
If $r_{i+1} > r_i$ and no coin at p_{i+1} or p_{i+2}

Move coin to p_{i+1}

If $r_{i-1} > r_i$ and no coin at p_{i-1} or p_{i-2}

Move the coin to p_{i-1}.

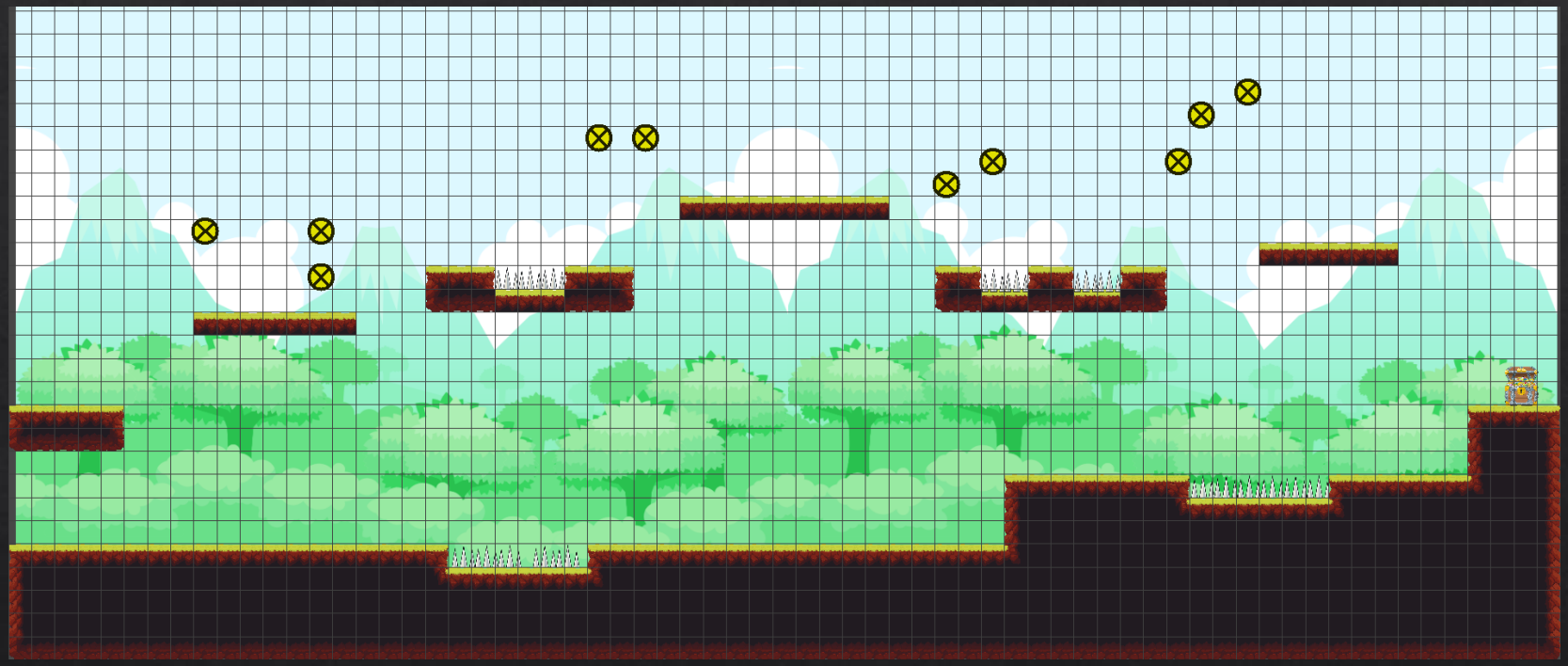
Iterate through all coins, moving each if needed until no coin moves



Path-Based Placement Algorithm

- *Outputs*

List of coin locations



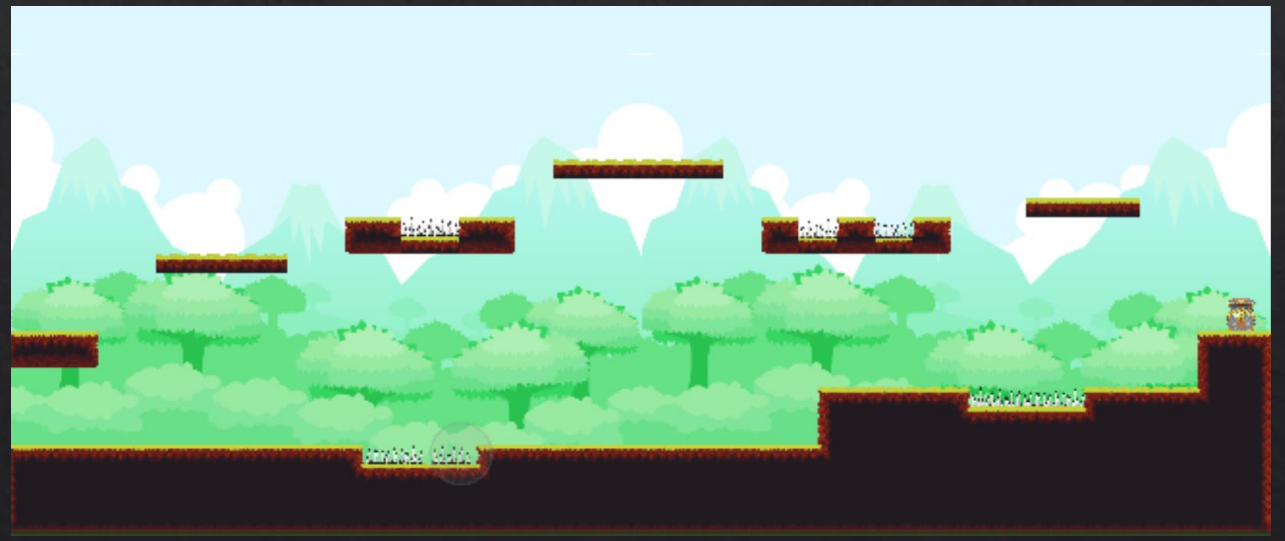
Participant Recruitment and Study

- Players recruited using Mechanical Turk

- Two Human Intelligence Tasks (HITs)
  - Player Trajectories
  - Coin Placement Evaluation

Player Trajectories HIT

- 200 participants (160 completed)
- No coins or associated UI
- Introductory level same for everyone, but remaining levels randomized
- Gathered trajectories of player movement during gameplay
- Data from this HIT only used to gather trajectories and not for evaluation

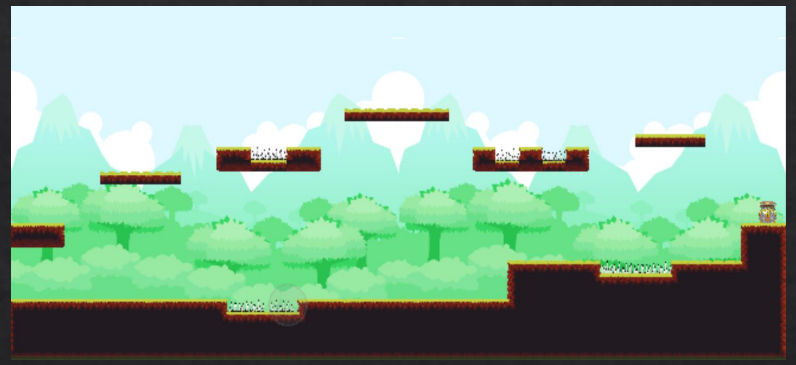


Path Evaluation HIT

- 1600 participants (1226 completed)
- Levels were served in order of decreasing player success rate from previous HIT
- Players randomly assigned into one of 4 conditions:

Path Evaluation HIT

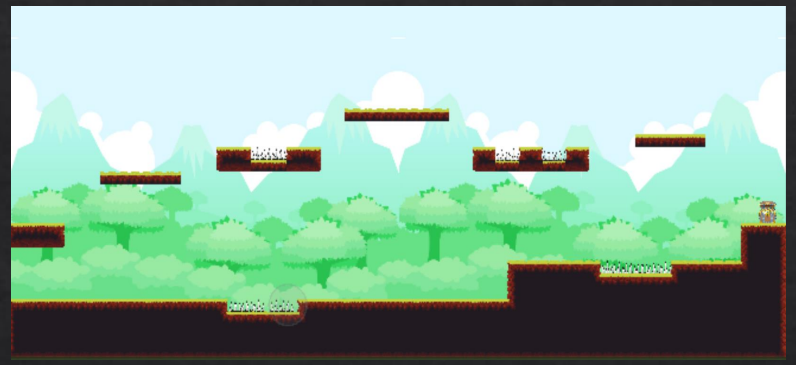
- 1600 participants (1226 completed)
- Levels were served in order of decreasing player success rate from previous HIT
- Players randomly assigned into one of 4 conditions:



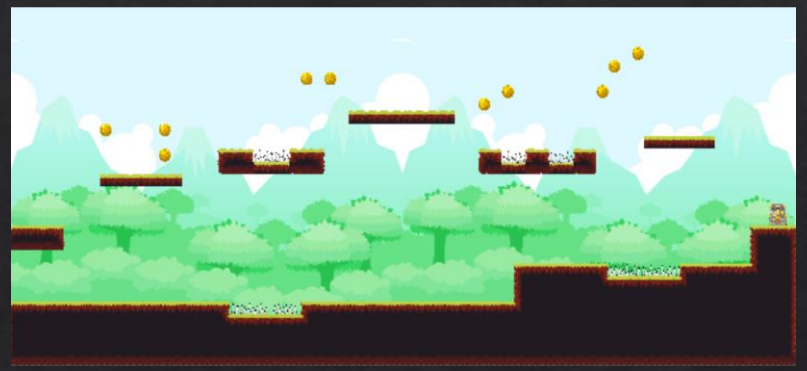
NONE

Path Evaluation HIT

- 1600 participants (1226 completed)
- Levels were served in order of decreasing player success rate from previous HIT
- Players randomly assigned into one of 4 conditions:



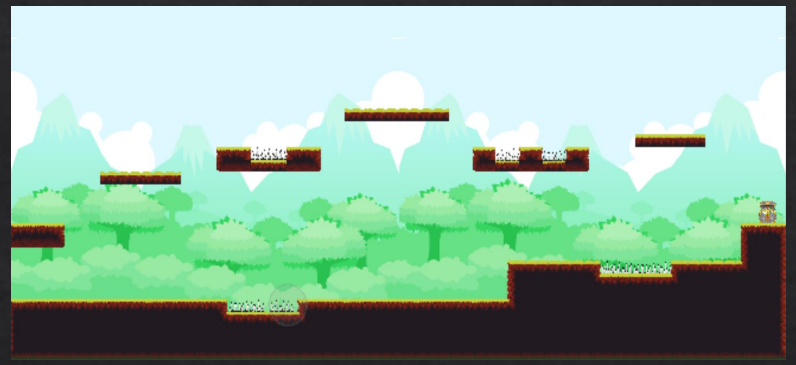
NONE



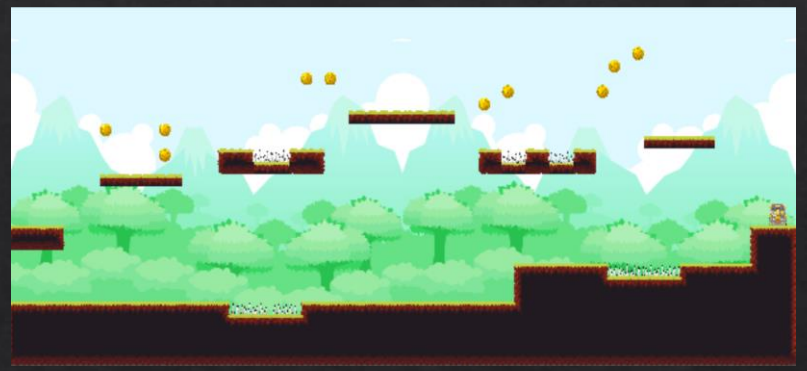
PATH

Path Evaluation HIT

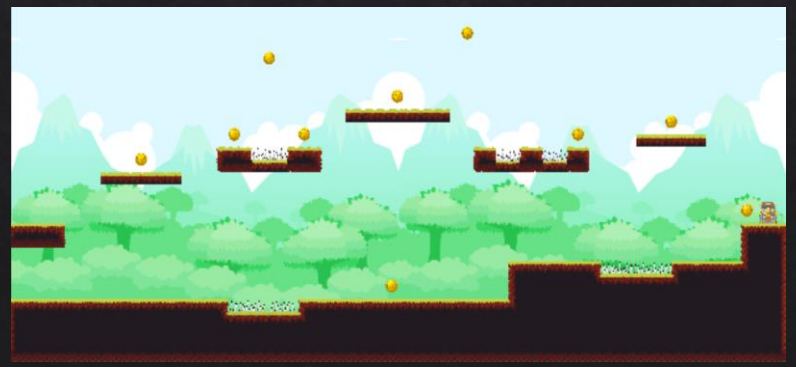
- 1600 participants (1226 completed)
- Levels were served in order of decreasing player success rate from previous HIT
- Players randomly assigned into one of 4 conditions:



NONE



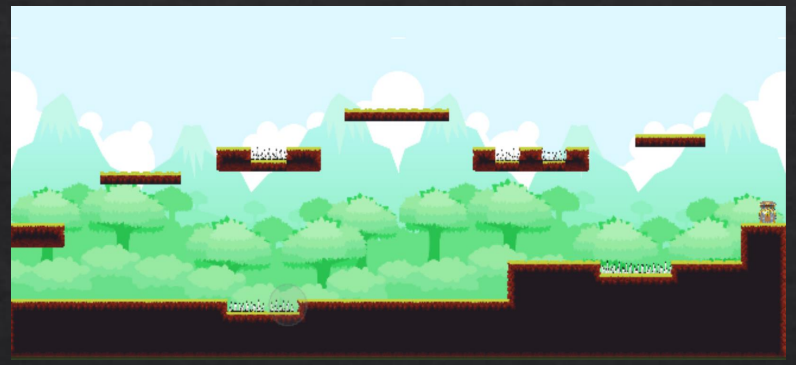
PATH



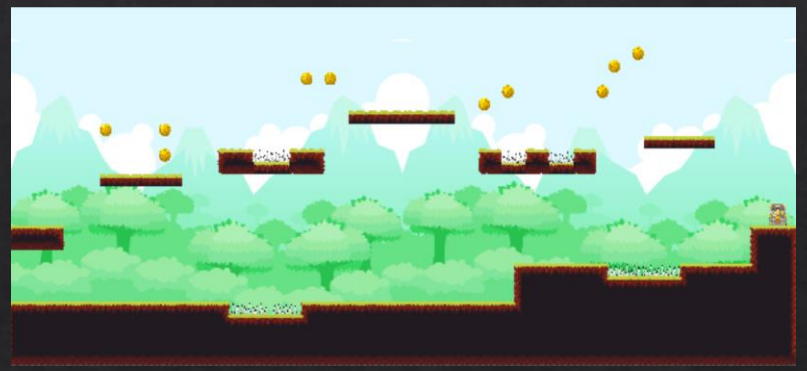
DSGN

Path Evaluation HIT

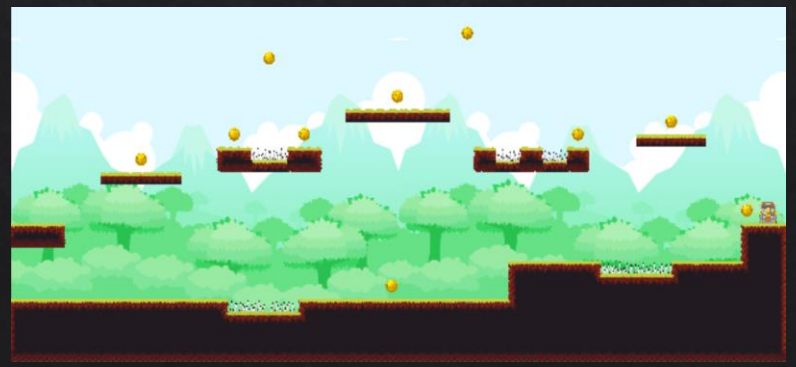
- 1600 participants (1226 completed)
- Levels were served in order of decreasing player success rate from previous HIT
- Players randomly assigned into one of 4 conditions:



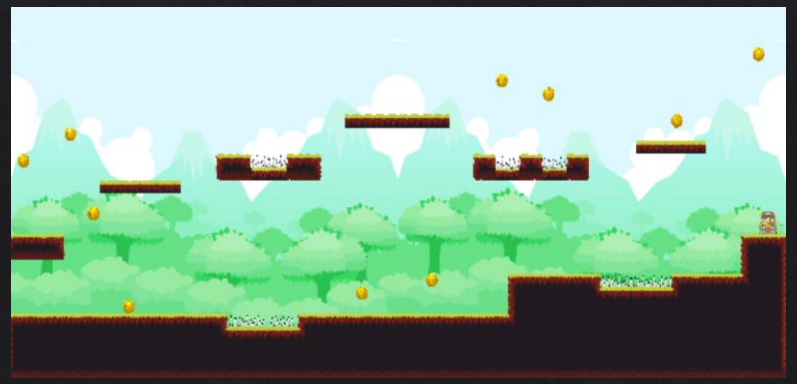
NONE



PATH



DSGN



RAND

Evaluation Measures

- *Levels Won*
- *Finish Rate*
- *Total Time*
- *Per-Level Time*
- *Total Coins*
- *Per-Level Coins*

Results

	NONE	PATH	DSGN	RAND
Levels Won	**5**	**4**	**4**	**3**
Finish Rate (%)	8	10	6	6
Total Time (s)	224	216	226	174
Per-Level Time (s)	**38**	**37**	**47**	**41**
Total Coins		**38**	**25**	**26**
Per-Level Coins		**8**	**6**	**6**

Statistical Tests: Omnibus Kruskal-Wallis Test, post-hoc Wilcoxon Rank-Sum Test

Results

	NONE	PATH	DSGN	RAND
Levels Won	**5**	**4**	**4**	**3**
Finish Rate (%)	8	10	6	6
Total Time (s)	224	216	226	174
Per-Level Time (s)	**38**	**37**	**47**	**41**
Total Coins		**38**	**25**	**26**
Per-Level Coins		**8**	**6**	**6**

Statistical Tests: Omnibus Kruskal-Wallis Test, post-hoc Wilcoxon Rank-Sum Test

Results

	NONE	PATH	DSGN	RAND
Levels Won	***5***	***4***	***4***	***3***
Finish Rate (%)	8	10	6	6
Total Time (s)	224	216	226	174
Per-Level Time (s)	***38***	***37***	***47***	***41***
Total Coins		**38**	***25***	***26***
Per-Level Coins		**8**	***6***	***6***

Statistical Tests: Omnibus Kruskal-Wallis Test, post-hoc Wilcoxon Rank-Sum Test

- Additional pair-wise similarities:
  - PATH & DSGN for *Levels Won*
  - RAND, PATH & NONE for *Per-Level Time*

Discussion

- Players collected more coins in PATH than in DSGN and RAND

Discussion

- Players collected more coins in PATH than in DSGN and RAND

- Players spent most time playing each level in DSGN

Discussion

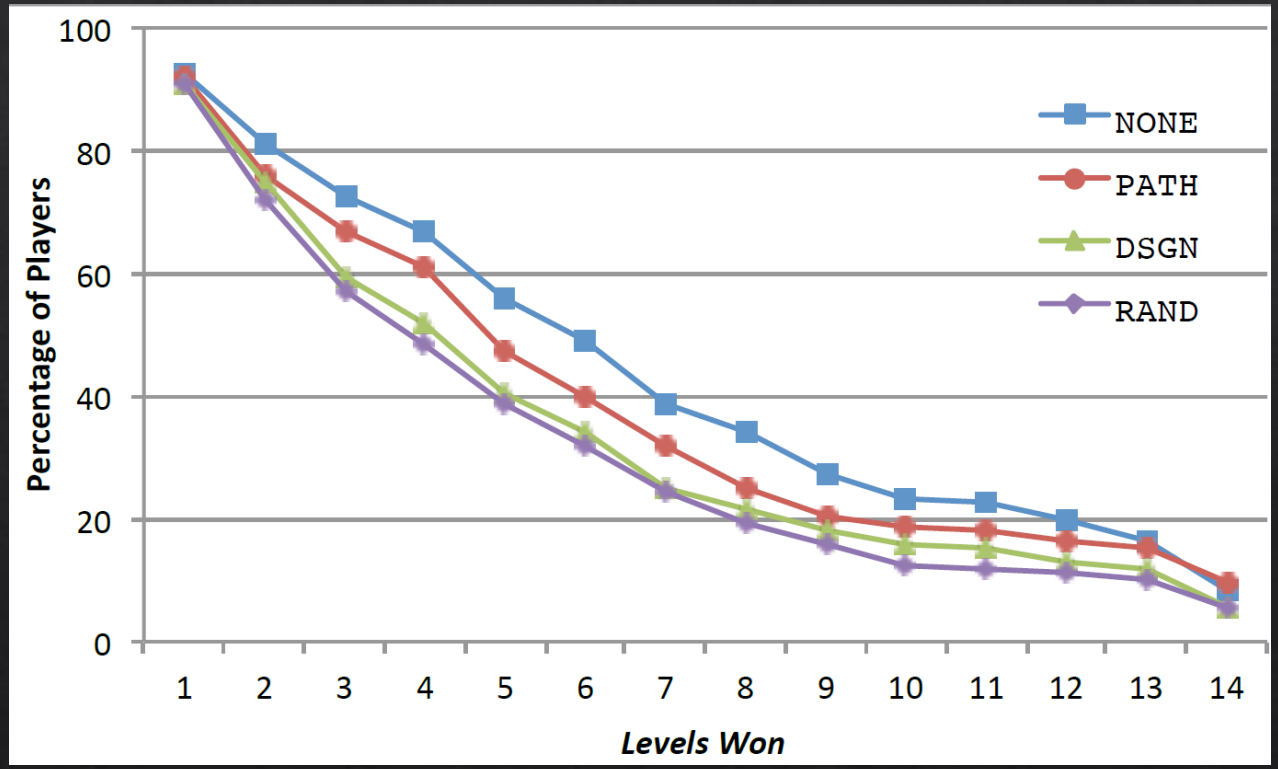
- Players collected more coins in PATH than in DSGN and RAND
- Players spent most time playing each level in DSGN
- Similar to Andersen et al., we found NONE and PATH to not be significantly different

Discussion

- While they saw upward trend for *time played* with on-path coins, we saw a downward trend for *time played* and *levels won*

Discussion

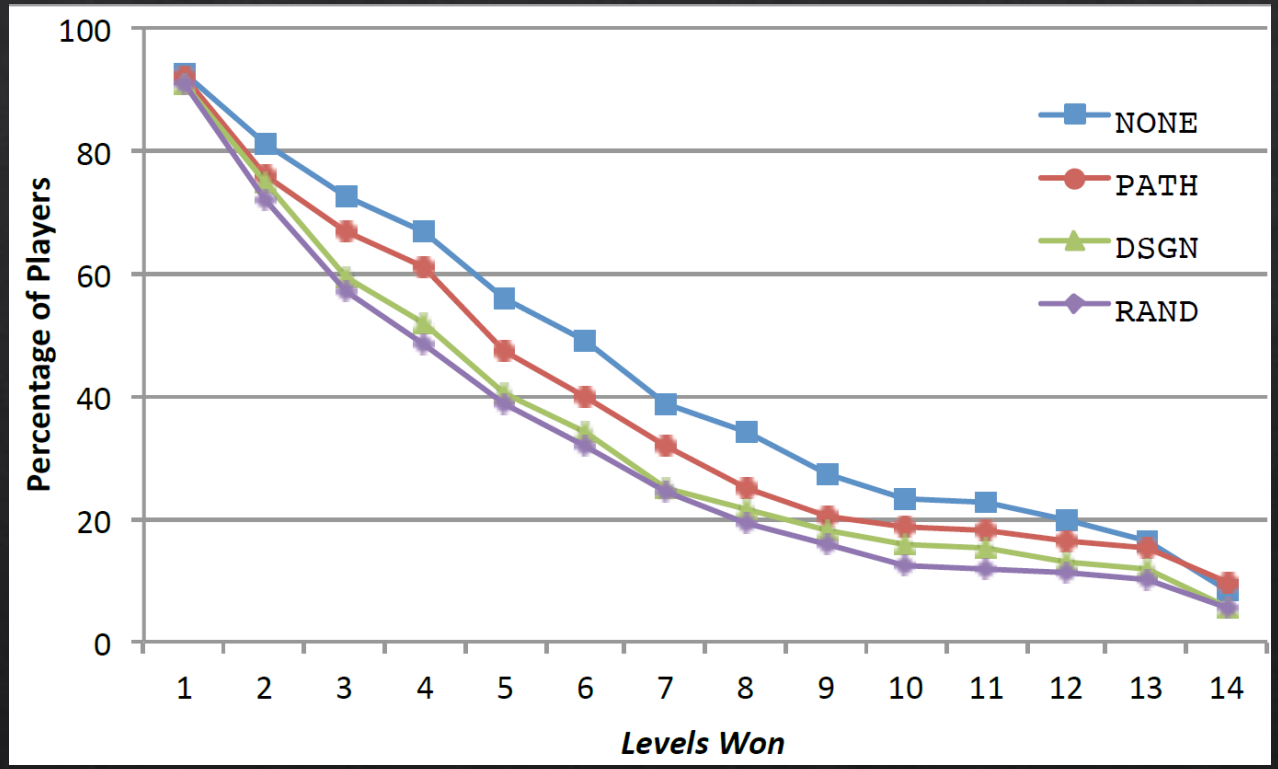
- While they saw upward trend for *time played* with on-path coins, we saw a downward trend for *time played* and *levels won*



Discussion

- While they saw upward trend for *time played* with on-path coins, we saw a downward trend for *time played* and *levels won*

- Path of coins may help player only if levels are sufficiently hard



Conclusion

- Absent of other utilities, collectibles do not necessarily incentivize players to complete more levels or play for longer even when serving primary objective

Conclusion

- Absent of other utilities, collectibles do not necessarily incentivize players to complete more levels or play for longer even when serving primary objective

- Collectibles might help only for sufficiently hard levels

Conclusion

- Absent of other utilities, collectibles do not necessarily incentivize players to complete more levels or play for longer even when serving primary objective
- Collectibles might help only for sufficiently hard levels
- Placement strategy depends on designer goals
  - PATH – help players complete levels more quickly
  - DSGN – make players explore more

Future Work

- Other games and genres
- Wider design space
- Subjective experience of players
- Other heuristics

Contact

Anurag Sarkar
Northeastern University
sarkar.an@husky.neu.edu

Acknowledgments

The authors would like to thank Liam Fratturo for the designer coin placement