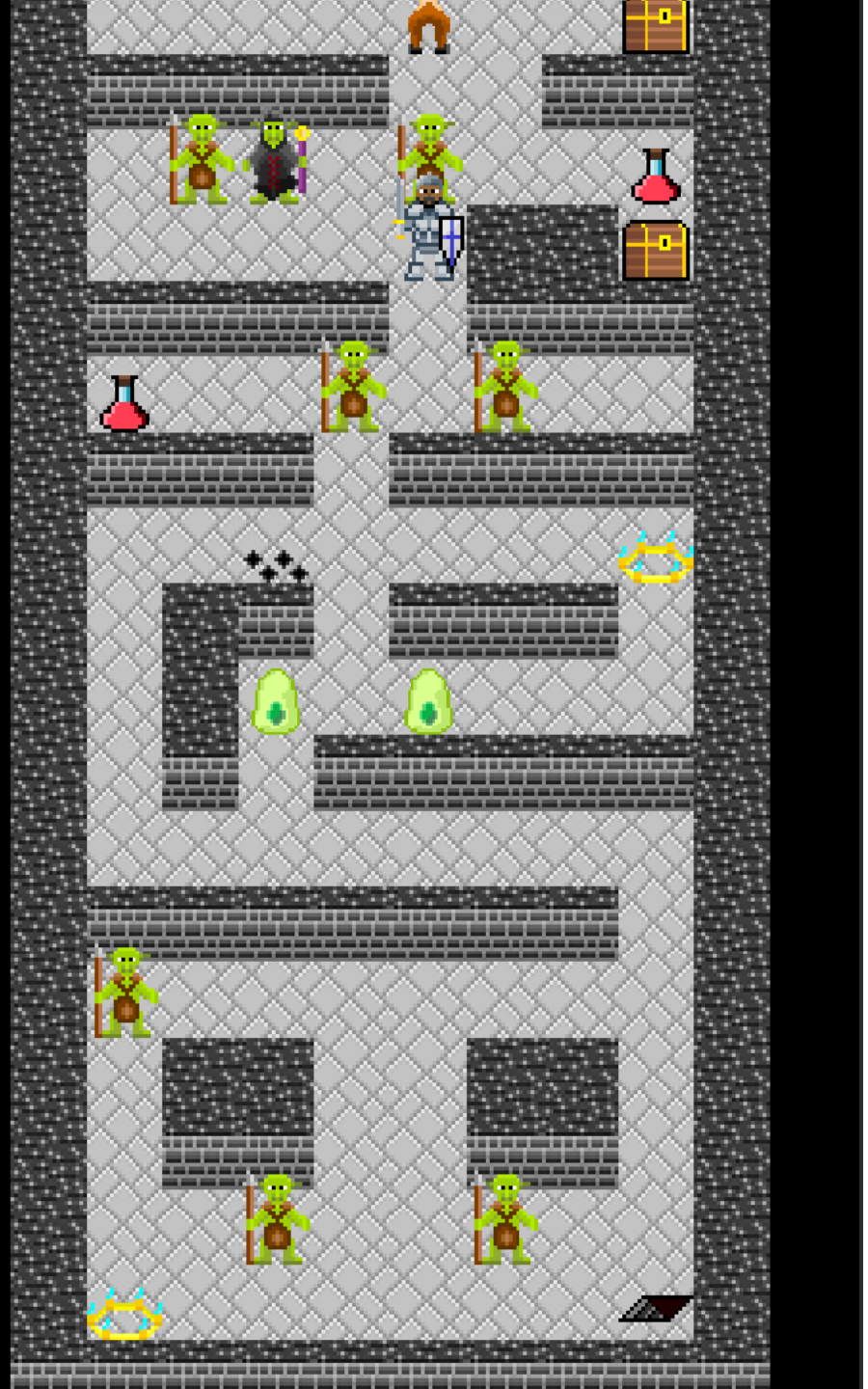
MCTS Personas for Minidungeons 2



MiniDungeons 2

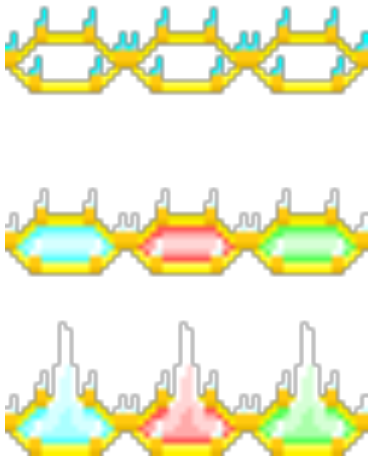
- 2d Rouge-like Dungeon Crawler
- Hero -> Exit
- Monsters, Traps, Potions, Treasures, Portals

Monsters

- Goblins (Melee and Wizards)
- Ogres
  - Like treasure
- Blobs
  - Eat potions
  - Combine with other blobs
- Minitaurs
  - Chase the player

Interactables

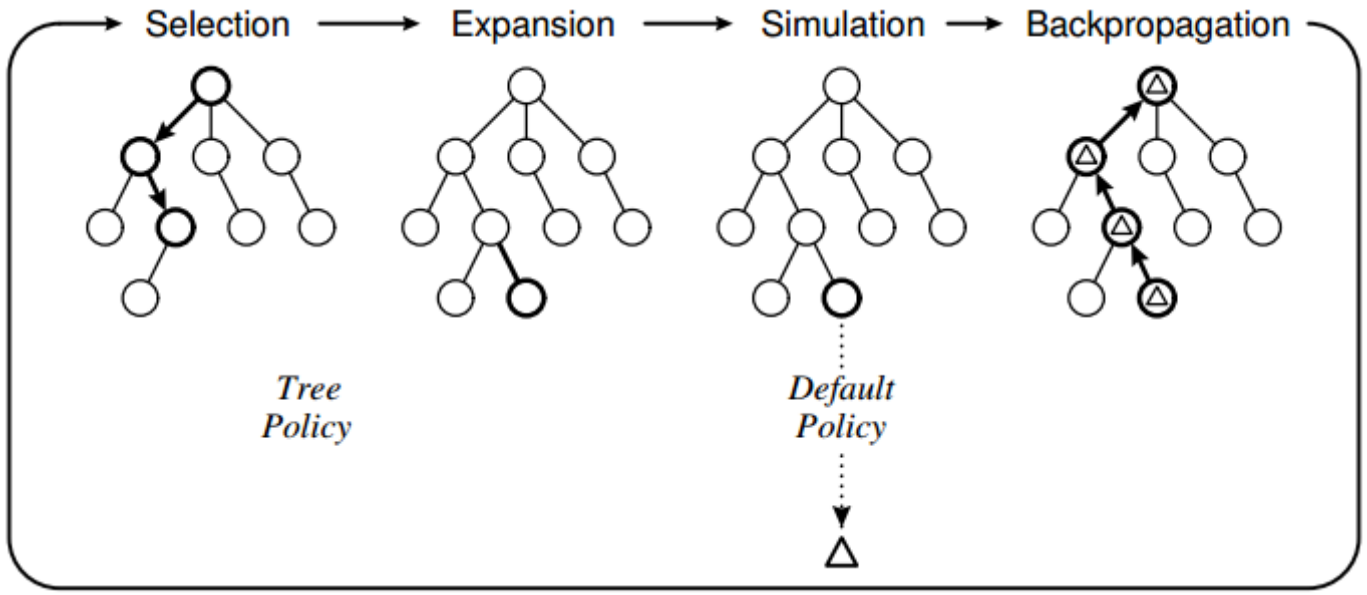
- Treasures
  - Coins!
- Potions
  - Restore HP
- Portals
  - Instantaneous travel
- Traps
  - Harm HP



4 Strategies, 4 Personas

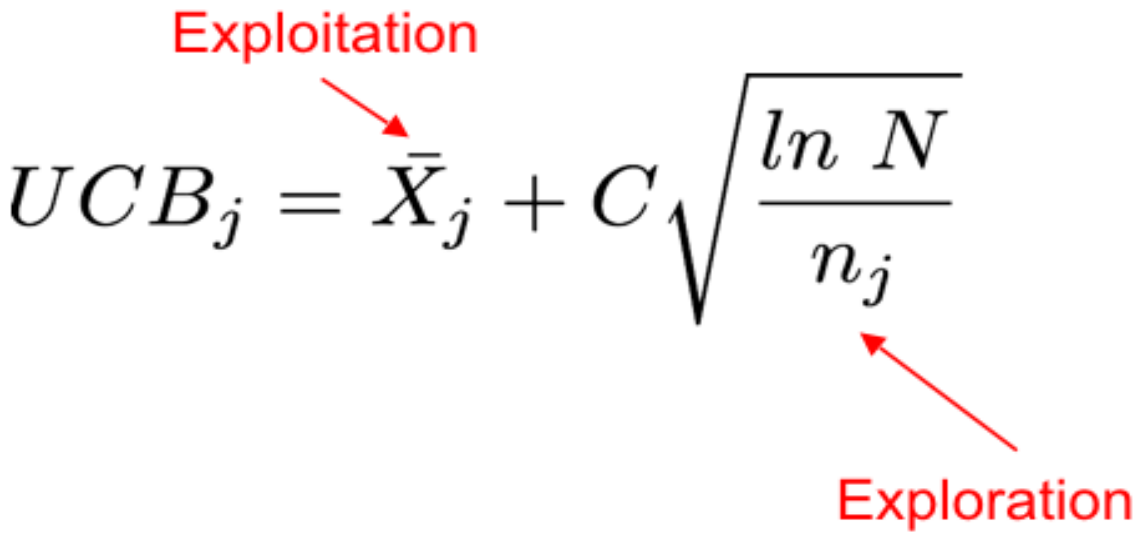
- Runner
  - MO: get to the exit
- Monster Killer
  - MO: Kill as many monsters as possible
  - SO: Get to the exit
- Treasure Collector
  - MO: Collect as much treasure as possible
  - SO: Get to the exit
- Completionist
  - MO: Interact with as many things as possible
  - SO: Get to the exit

Monte Carlo Tree Search



- Tree with Game States as nodes
- 4 Steps
  - Selection
  - Expansion
  - Simulation (Value calculated using a “Utility Function”)
  - Backpropagation

The UCB Equation (Selection)



- Exploration v Exploitation
- X_j = ratio of win states to visit states at node j
- C = constant
- N = total number of simulations
- n_j amount of times node j was visited

Evolution

1. Start with an random initial set of chromosomes
2. Calculate fitness
3. Crossover
4. Mutation
5. Go back to 2.

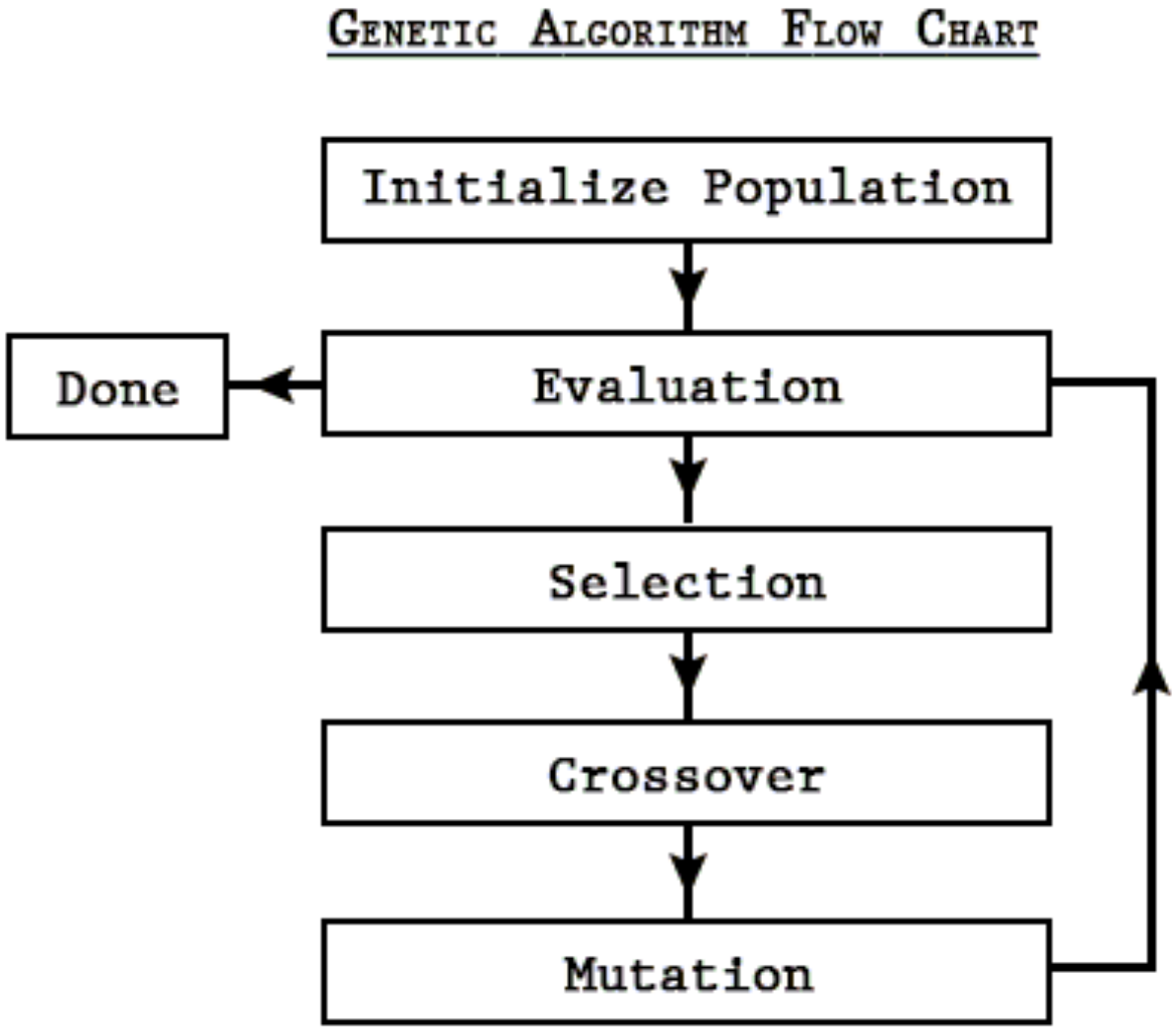
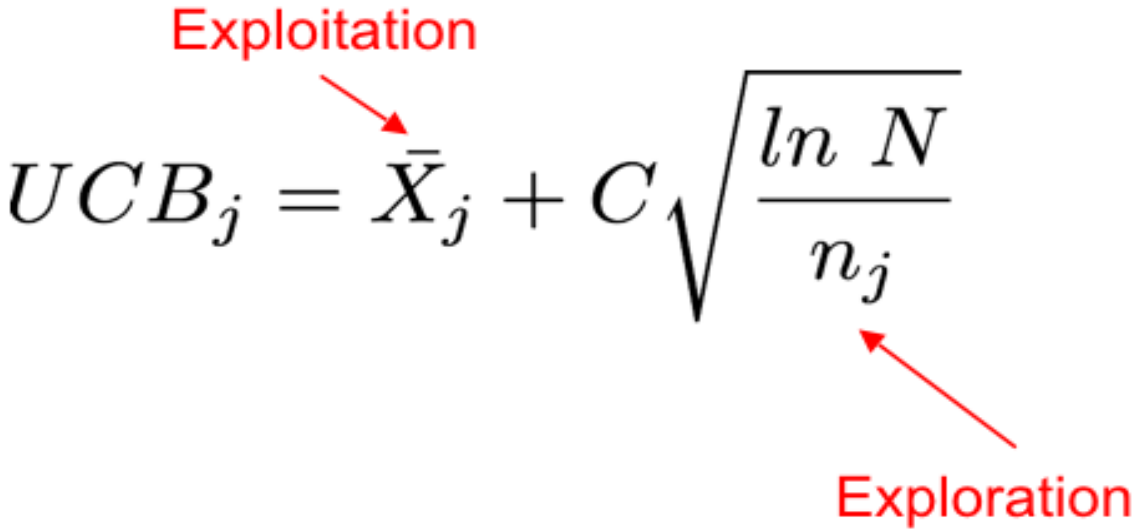


FIGURE 2

UCB Evolution

- Completely replace this equation for each chromosome



Persona Utility Functions

- Penalty for death
- Weighting forces a primary and secondary objective

$$U_R = \begin{cases} PE - 0.01 \times ST & \text{if hero is alive} \\ PE - 0.01 \times ST - 5 & \text{if hero is dead} \end{cases}$$

$$U_{MK} = \begin{cases} 0.7 \times MS + 0.3 \times PE & \text{if hero is alive} \\ 0.7 \times MS + 0.3 \times PE - 5 & \text{if hero is dead} \end{cases}$$

$$U_{TC} = \begin{cases} 0.7 \times TO + 0.3 \times PE & \text{if hero is alive} \\ 0.7 \times TO + 0.3 \times PE - 5 & \text{if hero is dead} \end{cases}$$

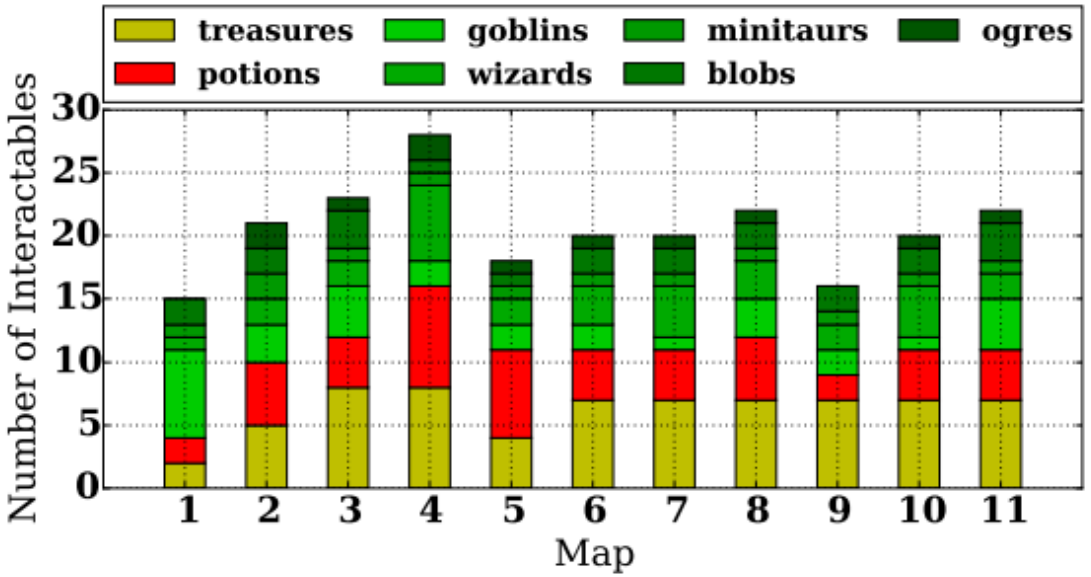
$$U_C = \begin{cases} 0.7 \times IR + 0.3 \times PE & \text{if hero is alive} \\ 0.7 \times IR + 0.3 \times PE - 5 & \text{if hero is dead} \end{cases}$$

Maps

evolved using Maps 1, 2, 3, 4, 7, 10

(a) Map 1 (b) Map 2 (c) Map 3 (d) Map 4 (e) Map 5 (f) Map 6 (g) Map 7 (h) Map 8 (i) Map 9 (j) Map 10 (k) Map 11

Fig. 1: All 11 maps in the *MiniDungeons 2* game.



After 100 Generations…

$$
\begin{aligned}
t_R &= 6.235 \times ST \times PE^2 \times (PE + 1) + R \times (1 - HL) \\
t_{MK} &= 4 \times MS \times PE \times (MS + 2 \times HL \times (PE - IC)) \\
t_{TC} &= 2 \times PD + 2 \times MS + TO \\
&\quad + 3 \times R + ST + PE + 0.19 \\
t_C &= ST \times MS \times (ST^2 \times MS + IC) + R - TO + IC \\
&\quad - PE + 2 \times ST \times PE \times (ST \times MS \times + 1)
\end{aligned}
$$

Note: Utility functions also used as Fitness Functions

Steps Taken (ST)	Proximity to Exit (PE)
Potions Drunk (PD)	Treasures Opened (TO)
Minitaur Knockouts (MTK)	Monsters Slain (MS)
Javelins Thrown (JT)	Health Left (HL)
Teleports Used (TU)	Traps Spring (TS)
Average MCTS reward ($\bar{R}$)	Interactables Consumed (IC)

TABLE II: Average scores in several game metrics for evolved and baseline personas. Results are averaged from 50 independent playthroughs of the best personas in each of the 11 levels. Results include the 95% confidence interval.

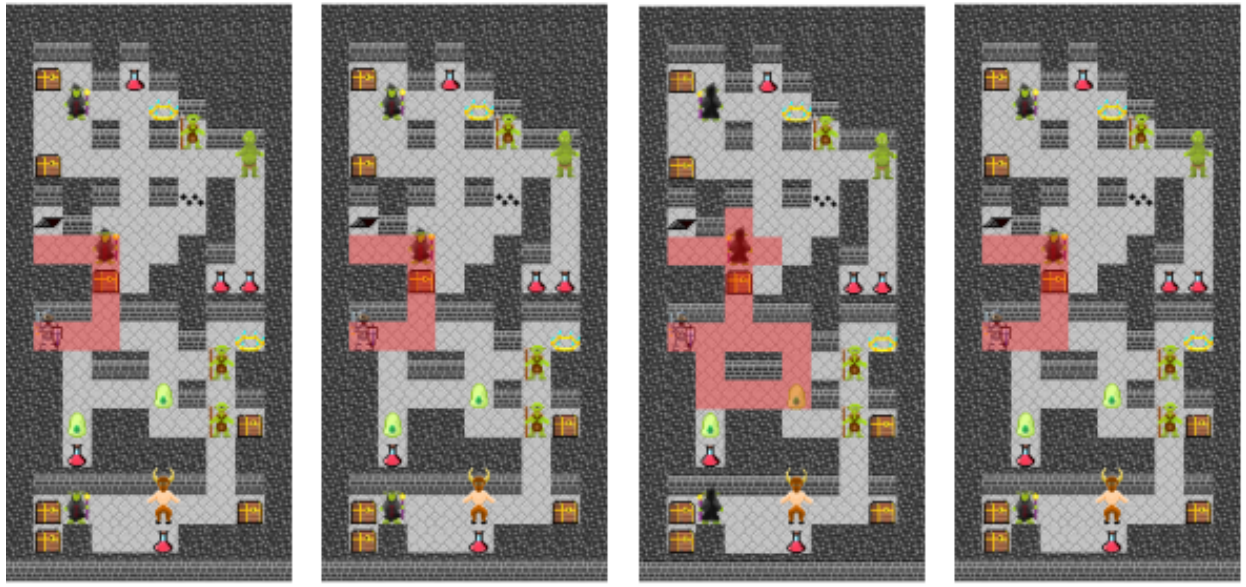
Metric	R	MK	TC	C
Baseline				
Monsters	25%±1%	29%±1%	25%±1%	28%±0%
Potions	5%±1%	5%±1%	6%±1%	5%±0%
Treasures	5%±1%	5%±1%	17%±2%	6%±0%
Interactables	13%±1%	16%±1%	19%±1%	15%±0%
Win Rate	10%±3%	12%±3%	9%±2%	13%±0%
Time (sec)	277±6	285±4	279±5	278±0
Evolved				
Monsters	46%±2%	67%±2%	59%±2%	66%±3%
Potions	8%±1%	4%±1%	25%±2%	8%±1%
Treasures	10%±1%	7%±1%	35%±2%	10%±1%
Interactables	25%±1%	33%±1%	41%±1%	34%±1%
Win Rate	100%±0%	73%±4%	54%±4%	100%±0%
Time (sec)	3.2±0.3	83±11	151±12	8.1±1.2

TABLE III: Levels in which the shown metrics are significantly higher for the evolved persona (E) than the baseline persona of the same type and levels in which the reverse is true (B).

	R		MK		TC		C	
Metric	E	B	E	B	E	B	E	B
Monster Ratio	8	1	10	0	10	1	10	0
Potion Ratio	2	0	2	1	8	1	2	0
Treasure Ratio	3	2	2	5	7	1	3	3
Interactable Ratio	9	1	10	0	10	1	10	0
Time (sec)	0	11	0	11	0	10	0	11
Win Rate	10	0	7	0	7	0	10	0

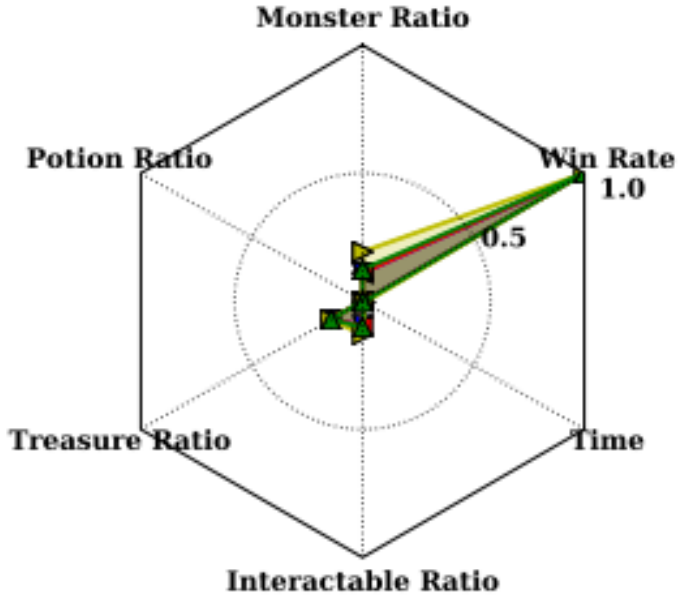
Comparison to “Vanilla” MCTS Personas

Sometimes They Act Similarly…



(a) R (b) MK (c) TC (d) C

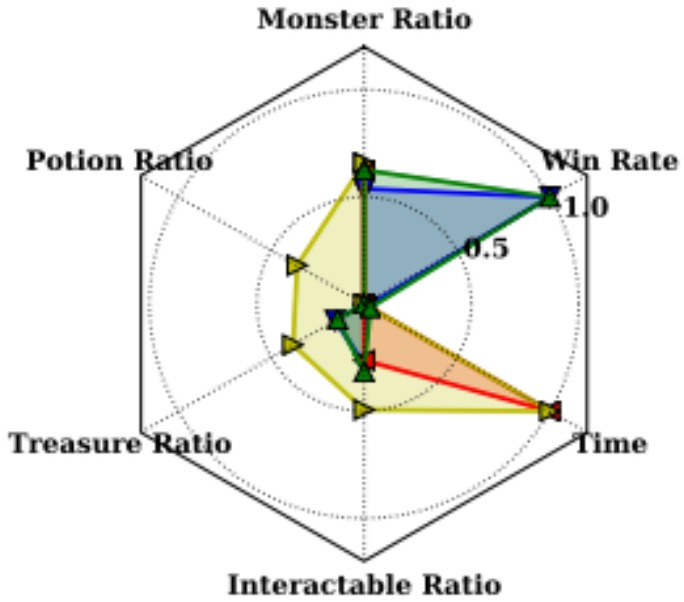
Fig. 5: Heatmaps of persona behavior in map 8.



Most Times They Don’t…

(a) R (b) MK (c) TC (d) C

Fig. 4: Heatmaps of persona behavior in map 6.



Take-aways

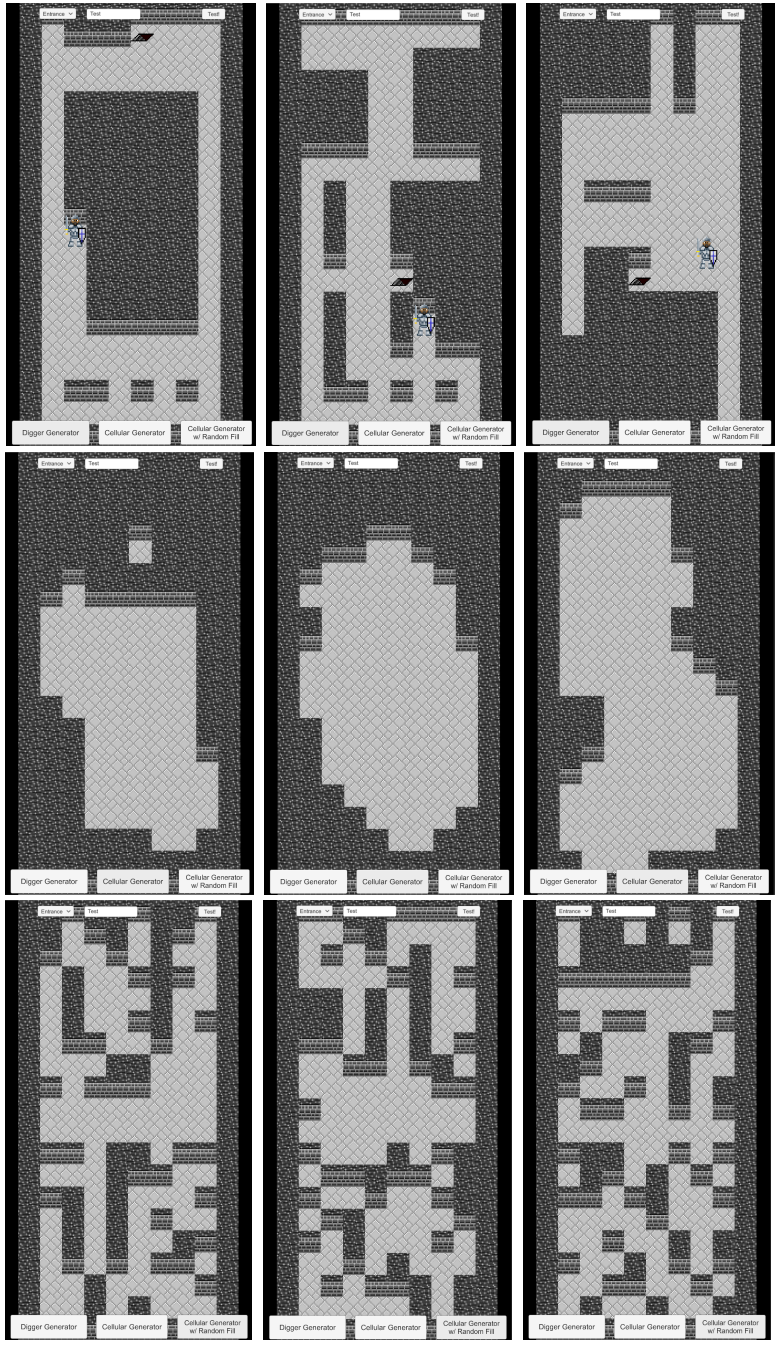
- Evolved Personas are
  - Faster
  - Winners
  - More Archetypal
  - Sensitive to different level patterns

TABLE III: Levels in which the shown metrics are significantly higher for the evolved persona (E) than the baseline persona of the same type and levels in which the reverse is true (B).

	R		MK		TC		C	
Metric	E	B	E	B	E	B	E	B
Monster Ratio	8	1	10	0	10	1	10	0
Potion Ratio	2	0	2	1	8	1	2	0
Treasure Ratio	3	2	2	5	7	1	3	3
Interactable Ratio	9	1	10	0	10	1	10	0
Time (sec)	0	11	0	11	0	10	0	11
Win Rate	10	0	7	0	7	0	10	0

Future Work

- Constructive Level Generation
- Use Personas as Level Design Tools
- Results used to inform Game Designers

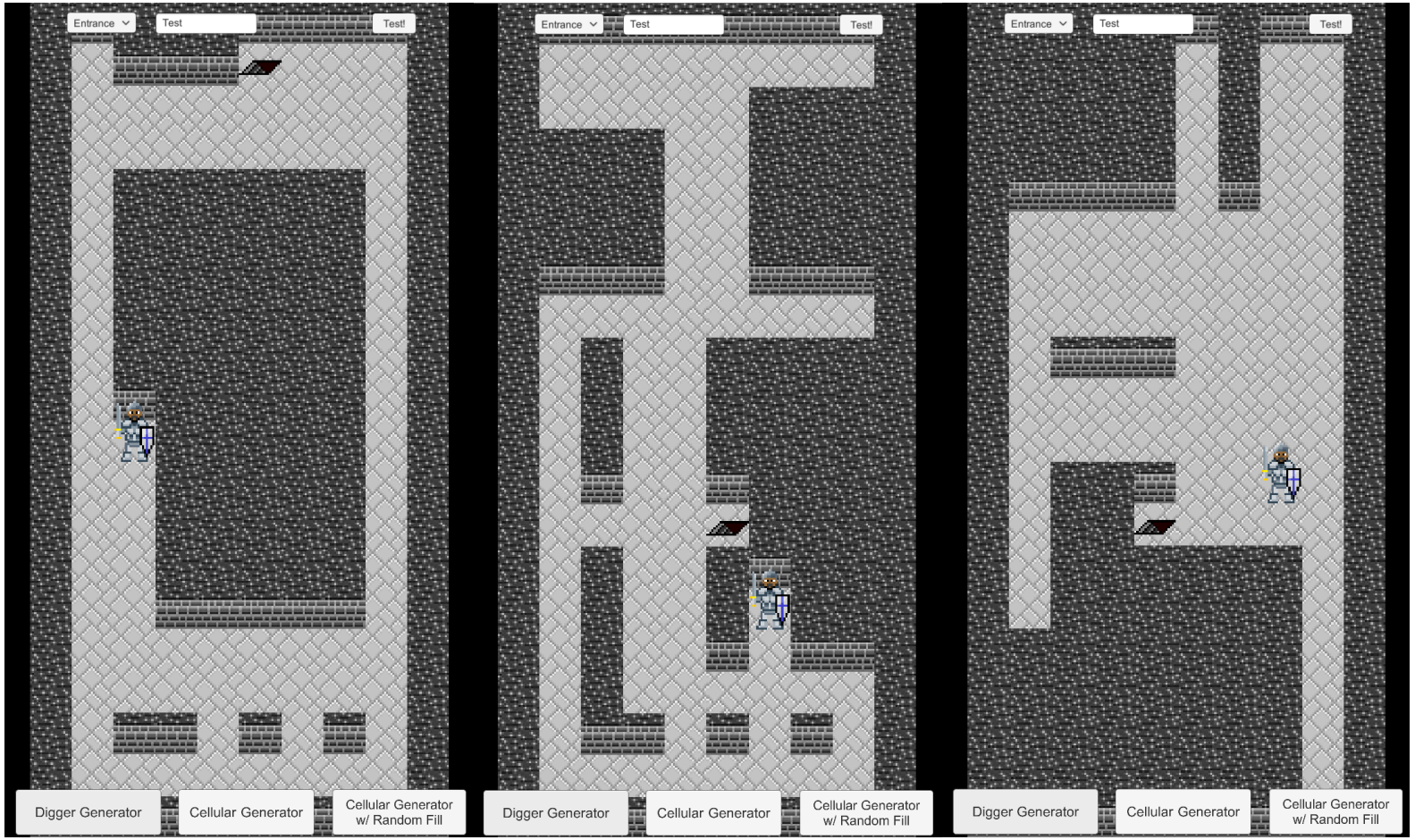


Constructive Generation

- Digger Agent
- Cellular Automata
- Multi-layered Cellular Automata
- Grammar-Based (not built yet)

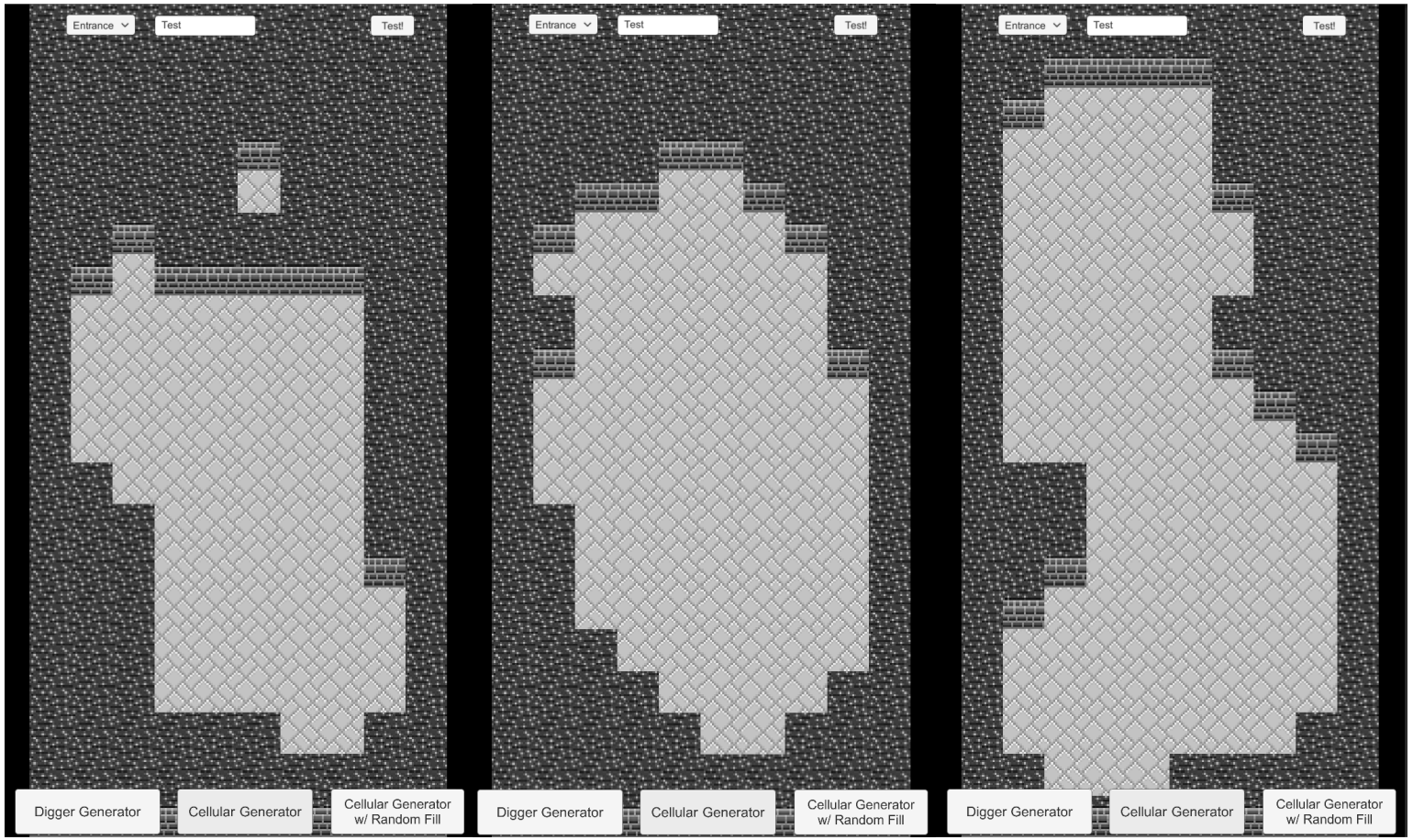
Digger Agent

1. Randomly Placed on Map
2. Digs out space
3. Choose Direction (random probability)
4. Move forward, go to Step 2



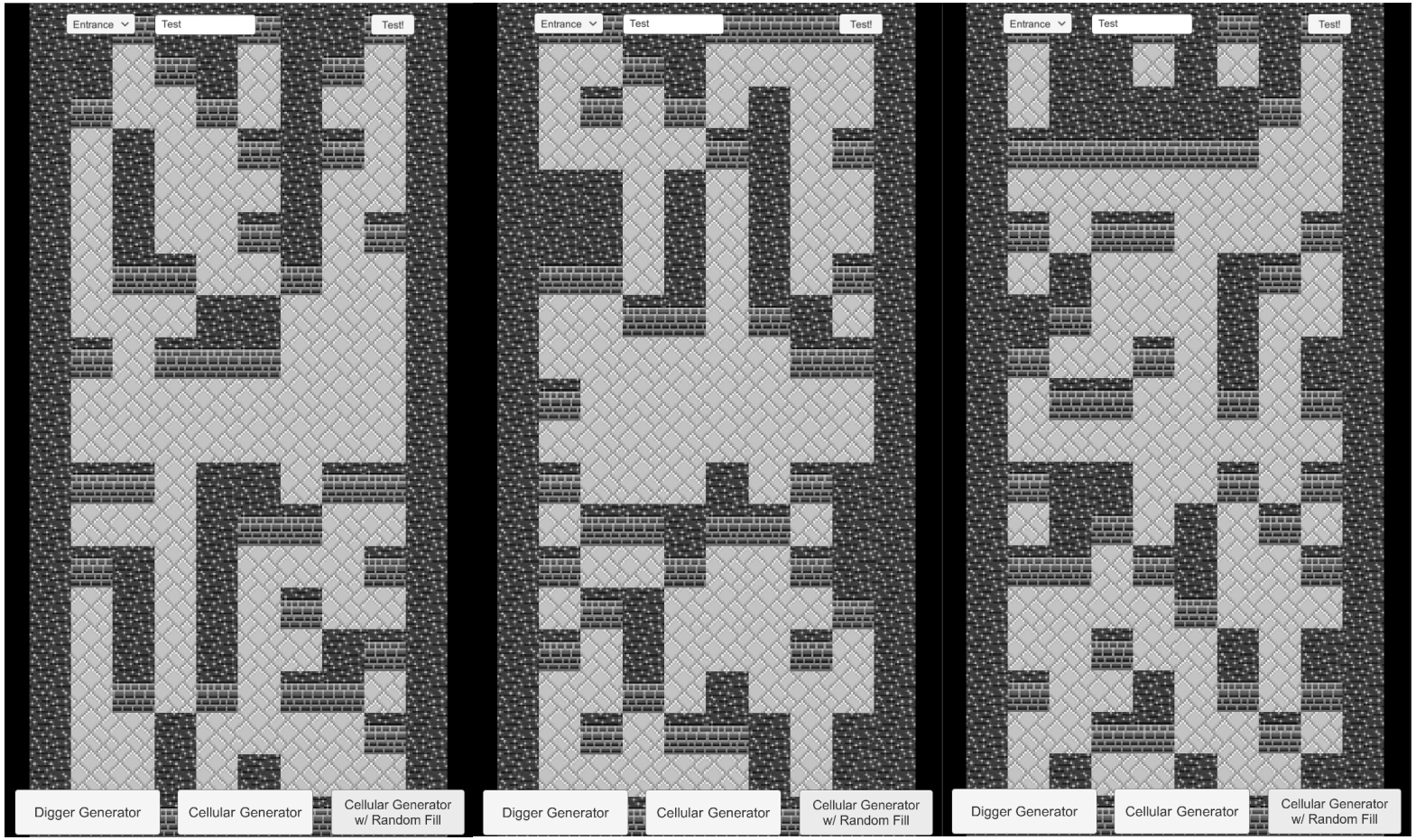
Cellular Automata

- Randomizes walls and empty tiles on a blank map (40%)
- Performs Cellular Automata on map to smooth out
- Done



Multi-layered Cellular Automata

- Randomizes walls and empty tiles on a blank map (40%)
- Performs Cellular Automata on map to smooth out
- Perform cellular automata again and again with decreasing amounts of randomness



Population

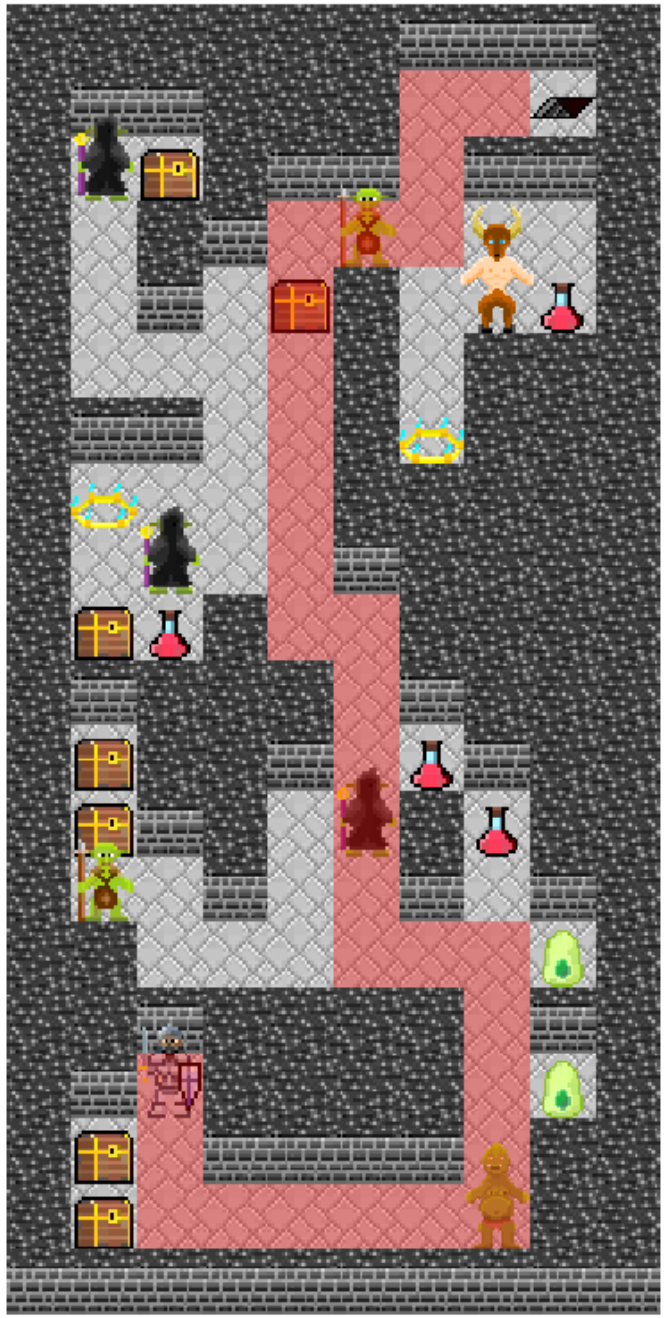
- Random Population (Terrible)
- Cellular Automata
- Agent-Based
- Proximity Probability
- Another way?

Evaluation for Generating

- Length of shortest path from entry to exit
- Degree of path branching
- Proportion of free space to “filled” space
- Number of connected components (freestanding objects)

Evaluation for Populating

- Spatial entropy (as in Shannon entropy) of treasures/ monsters
- How much are treasures and potions hidden behind monsters
- How many monsters on the shortest path



Evaluation

- Evolved MCTS Agent Gameplay
  - Runner
  - Treasure Collector
  - Monster Killer
  - Completionist
- Comparison analysis on the results of playthroughs