

# 2105029 Report

The UI was made using Node and React JS. Game Engine (Backend) was implemented using C++. The implementation was made versatile so that it can receive command line arguments to select heuristic, depth of search and which color to play for.

## Experimental Setup:

Minimax algorithm with alpha-beta pruning was implemented. The following heuristics were developed:

1. **Tile Count:** The agent prioritizes filling the board in such a way that maximum number of tiles are filled with its playing color.
2. **Orb Count:** Similar to tile count, but it considers the total number of orbs that are of its playing color. Intuitively, this is expected to perform better than tile count (and it does so).
3. **Boundary Control:** As orbs in the boundaries and corners are more likely to react quickly (their critical masses being low i.e. 2 for corners and 3 for boundaries compared to 4 for other tiles), the agent prioritizes to gain control over those tiles, while trying to fill more tiles with its playing color.
4. **Stack Control:** Stacking orbs are crucial to cause a reaction, and this agent prioritizes having more chances of causing reaction up its arsenal (interesting data observed).
5. **Orb Boundary Mix:** This agent uses both orb count and the boundary control heuristics. A formidable opponent.
6. **Random Move:** This agent randomly places orbs in the board where it can. Weakest agent. Is not influenced by AI depth.

## Statistics:

Performance: AI Depth = 2

Against-> Win rate of:	Tile Count	Orb Count	Boundary Control	Stack Control	Orb Boundary Mix	Random
Tile Count	-	25.5%	29.4%	18.87%	19.35%	100%
Orb Count	74.5%	-	62.75%	38.6%	39.9%	93.33%
Boundary Control	70.6%	37.25%	-	15.7%	32.7%	100%
Stack Control	81.13%	61.4%	84.3%	-	61.7%	97.06%
Orb Boundary Mix	80.65%	60.1%	67.3%	38.3%	-	100%
Random	0%	6.67%	0%	2.94%	0%	-

Ranking after comparative strength analysis: (High to Low)

1. Stack Control
2. Orb Boundary Mix
3. Orb Count
4. Boundary Control
5. Tile Count
6. Random

### Average Match Duration: AI Depth = 2

Against-> Time taken by:	Tile Count	Orb Count	Boundary Control	Stack Control	Orb Boundary Mix	Random
Tile Count	-	17.82s	18s	21.6s	17.75s	11.61s
Orb Count	17.82s	-	19.08s	21.53s	19.39s	11.55s
Boundary Control	18s	19.08s	-	21.98s	18.78s	11.48s
Stack Control	21.6s	21.53s	21.98s	-	21.89s	11.76s
Orb Boundary Mix	17.75s	19.39s	18.78s	21.89s	-	11.28s
Random	11.61s	11.55s	11.48s	11.76s	11.28s	-

### No. of matches Simulated:

- Tile Count vs Orb Count: 51
- Tile Count vs Boundary Control: 51
- Tile Count vs Stack Control: 53
- Tile Count vs Orb Boundary Mix: 124
- Tile Count vs Random: 29
- Orb Count vs Boundary Control: 51
- Orb Count vs Stack Control: 101
- Orb Count vs Orb Boundary Mix: 188
- Orb Count vs Random: 30
- Boundary Control vs Stack Control: 51
- Boundary Control vs Orb Boundary Mix: 52
- Boundary Control vs Random: 43
- Stack Control vs Orb Boundary Mix: 141
- Stack Control vs Random: 34
- Orb Boundary Mix vs Random: 30

**Total Time taken = 5hrs 17mins 50s**

## Statistics:

Random was not included in this depth test as it was the worst before.

### Performance: AI Depth = 3

Against-> Win rate of:	Tile Count	Orb Count	Boundary Control	Stack Control	Orb Boundary Mix
Tile Count	-	38.1%	41.67%	40.38%	27.08%
Orb Count	61.9%	-	36.78%	62.96%	29.5%
Boundary Control	58.33%	63.22%	-	64.4%	37.5%
Stack Control	59.62%	37.04%	35.6%	-	41.27%
Orb Boundary Mix	72.92%	70.5%	62.5%	58.73%	-

Ranking after comparative strength analysis: (High to Low)

1. Orb Boundary Mix
2. Boundary Control
3. Orb Count
4. Stack Control
5. Tile Count

### Average Match Duration: AI Depth = 3

Against-> Time taken by:	Tile Count	Orb Count	Boundary Control	Stack Control	Orb Boundary Mix
Tile Count	-	2m 32s	1m 57s	5m 3s	2m 17s
Orb Count	2m 32s	-	2m 43s	3m 2s	2m 42s
Boundary Control	1m 57s	2m 43s	-	2m 46s	2m 36s
Stack Control	5m 3s	3m 2s	2m 46s	-	2m 56s
Orb Boundary Mix	2m 17s	2m 42s	2m 36s	2m 56s	-

### No. of matches Simulated:

- Tile Count vs Orb Count: 63
- Tile Count vs Boundary Control: 51
- Tile Count vs Stack Control: 52
- Tile Count vs Orb Boundary Mix: 48
- Orb Count vs Boundary Control: 60
- Orb Count vs Stack Control: 54
- Orb Count vs Orb Boundary Mix: 61
- Boundary Control vs Stack Control: 59
- Boundary Control vs Orb Boundary Mix: 53
- Stack Control vs Orb Boundary Mix: 63

**Total Time taken = 1d 2hrs 48 mins 35s**

## Analysis:

- Since random is not intelligent at all, we conclude that Tile Count heuristic is the weakest, even across varying depths. But is challenging as an opponent when played against as human.
- Stack control is the strongest at depth 2, but is the 2<sup>nd</sup> weakest at higher depth (3).
- Orb Count is the generally strong heuristic, securing 3<sup>rd</sup> place in both depths.
- Boundary Control proves to be better than Orb Count at higher depth.
- Orb Boundary Mix is always better than its constituent separate heuristics: Orb Count and Boundary Control, and it is the bests at higher depth.