

(added these guys as a cheer up)

1. I counted in a group of empty, opponent, and current player “pucks”. I looked in groups of 4 (4 circles) side to side, up and down, and diagonal down and uphill. This is in my `eval_function` with the point breakdown of utility. Utility was constantly added upon totalled to the board.

<code>current == 3 and empty == 1</code>	High increase in score +200
<code>current == 2 and empty == 2</code>	Small increase in score +50
<code>current == 1 and opponent == 3:</code>	Very high score (to make sure we blocked the player) +1000
<code>opponent == 3 and empty == 1:</code>	Very low negative score -infinity (we don't want this to happen)
<code>Current -- 4</code>	End State, terminal state, best for the current player +infinity

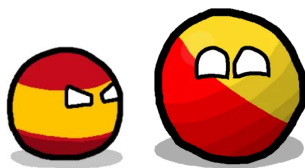
The reason for this numbering is that I had the situation of vision. We need to look at groups of 4 (the 4 circles) in order to see whether there was a possibly a good move coming up or an immediate need of countering the opponent’s winning move. I decided to weigh heavily (in current player) on making sure the opponent would not get a chance to win in any situation by taking a more defensive stance. Adding a large weight of utility or subtracting a large negative value when a move would negatively affect the player currently.

- 2.

The highest depth that I was able to test was 6. 6 overall performed the strongest, but took the longest amount of time per turn.

AI vs AI

	Depth = 1	Depth = 2	Depth = 3	Depth = 4	Depth = 5	Depth = 6
5 seconds	Red AI won after 7 moves	Yellow AI won after 17 moves	Red AI won after 7 moves	Stalemate at move 38	Stopped after move 1 Exception: Player Exceeded time limit	Stopped after move 1 Exception: Player Exceeded time limit
10 seconds	Red AI won after 7 moves	Yellow AI won after 16 moves	Red AI won after 7 moves	Stalemate at move 38	Stopped after move 5 Exception: Player Exceeded time limit	Stopped after move 3 Exception: Player Exceeded time limit



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3 seconds	Red AI won after 7 moves	Yellow AI won after 15 moves	Red AI won after 7 moves	Stalemate at move 38	Stopped after move 1 Exception: Player Exceeded time limit	Stopped after move 1 Exception: Player Exceeded time limit
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Highest recorded exploration was depth = 2 and depth = 4. However, depth = 2 resulted in a stalemate.

AI vs Human

	Depth = 1	Depth = 2	Depth = 3	Depth = 4	Depth = 5	Depth = 6
5 seconds	x	x	x	Yellow AI won after 36 moves	Stopped after move 3 Exception: Player Exceeded time limit	Overtime
10 seconds	x	x	x	Yellow AI won after 36 moves	Stopped after move 3 Exception: Player Exceeded time limit	Overtime
3 seconds	x	x	x	Yellow AI won after 36 moves	Stopped after move 0: Time limit exceeded	Overtime

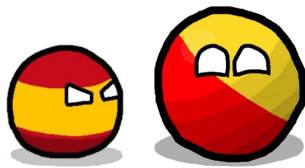
Clearly anything below 4 had no problems with completing a game. I decided not to play them out again and again with the given time constraints (played the game prior to testing around 50 times already). I found that the AI could win or lose depending on my level of alertness and willingness to finish each game. Each of those games concluded with no issues.

Time 6 was far too slow to even get past the 10 second bar.

AI v. human is very dependent on how effective the human is playing each time and this will affect what moves the person or the AI will need to explore at that given game.

AI vs Random

	Depth = 1	Depth = 2	Depth = 3	Depth = 4	Depth = 5	Depth = 6
5 seconds	Yellow AI won after 4 moves	Yellow AI won after 4 moves	Yellow AI won after 4 moves	OVERTIME	OVERTIME	Yellow AI won after 4 moves
10 seconds	Yellow AI won after 4 moves	Yellow AI won after 4 moves	Yellow AI won after 4 moves	Yellow AI won after 6 moves	OVERTIME	Yellow AI won after 4 moves
3 seconds	Yellow AI won after 4 moves	Yellow AI won after 4 moves	Yellow AI won after 4 moves	OVERTIME	OVERTIME	Yellow AI won after 4 moves



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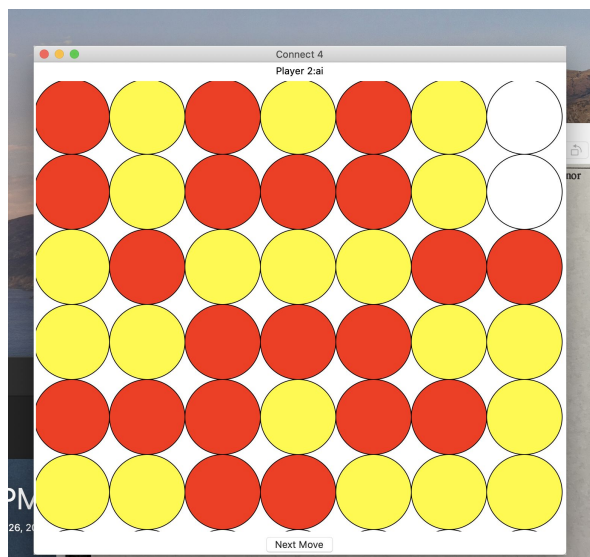
The AI seemed to explore “more” as depth increases. However, my algorithm timed out after 4-5 depth, but for 6 I had no issues.

3. The AI appears to beat the AI in various cases. This situation only happens if the entire board is nearly full and nearly all possible empty spaces are exhausted (example depth = 4). I cannot seem to beat my own AI after depth 3. In my 15 times playing my AI in its best form (Depth = 5+), I was able to beat it once with a move on the lowest row and columns 3-6 repeatedly. However, I fixed that mishap in my heuristics and cannot seem to beat it again.

I would again highlight that beating my algorithm depends on my mental alertness of the time. Playing at 3 am proved that I would quickly lose in 6 moves compared to a 1pm game which could last 20 moves.

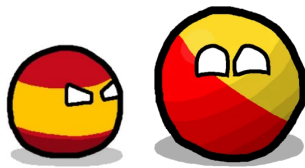
4. It seems dependent on depth. Data from question 2, Ai vs Ai points to displays that starting moves do not gain any benefit in winning the game. However, I can conclude at each depth there appears to be a definite defined winner. For example, Red AI always seems to win despite starting at turn two at depths 1 and 3 while depth equaling to 2 have yellow winning. 4 gave the odd case of tying nearly every round.

Here is an example of Ai vs Ai in Depth of 4

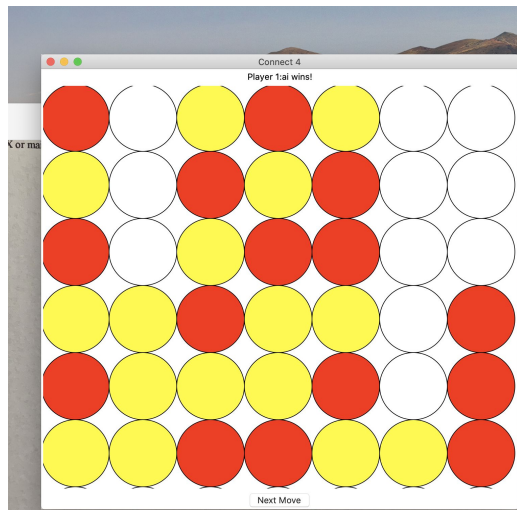


This resulted in a repeated stalemate, no matter who started.

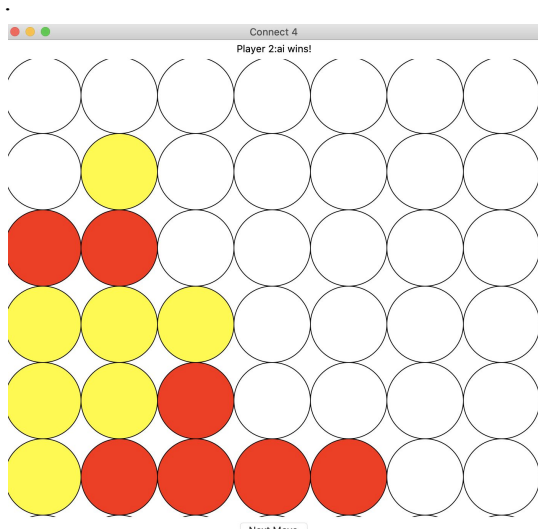
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Yellow won in this situation. Ai vs Ai in Depth of 2



In this case of depth = 3. The red AI won.