Alex Ottelien, Kyle Senebouttarath
4/26/2023
CS 3851 Combined
Dr. Nowling

Games of Differing Sampled Paths for 100 Games (RNG Player Goes First)

Type of Game (RNG goes first)	**Run Time (for 100 games) in seconds**	**Number Turns Played**	**Winner Percentages**
RNG v RNG	0.04	20.78	50
Intelligence (P=1) v RNG	1.07	22.27	43
Intelligence (P=2) v RNG	2.296	20.1	56
Intelligence (P=3) v RNG	3.72	20.44	66
Intelligence (P=4) v RNG	5.9	21.19	73
Intelligence (P=5) v RNG	7.69	19.78	76
Intelligence (P=6) v RNG	10.31	19.73	75
Intelligence (P=7) v RNG	12.27	19.36	71
Intelligence (P=8) v RNG	17.17	18.86	66
Intelligence (P=9) v RNG	19.9	18.89	75
Intelligence (P=10) v RNG	23.51	20.94	72

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Games of Differing Sampled Paths for 100 Games (AI Player Goes First)

Type of Game (AI goes first)	**Run Time (for 100 games) in seconds**	**Number Turns Played**	**Winner Percentages**
RNG v RNG	0.04	20.78	50
Intelligence (P=1) v RNG	4.63	21.22	62
Intelligence (P=2) v RNG	13.08	20.03	73
Intelligence (P=3) v RNG	24.13	20.61	71
Intelligence (P=4) v RNG	37.95	18.75	77
Intelligence (P=5) v RNG	64.15	20.55	79
Intelligence (P=6) v RNG	76.02	16.99	79
Intelligence (P=7) v RNG	107.77	18.16	78
Intelligence (P=8) v RNG	113.84	19.24	78
Intelligence (P=9) v RNG	167.86	18.2	86
Intelligence (P=10) v RNG	174.47	18.55	85

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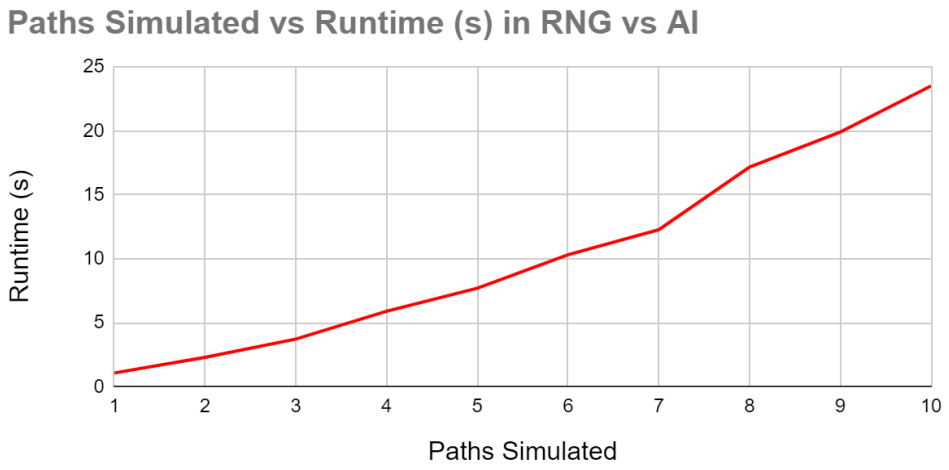
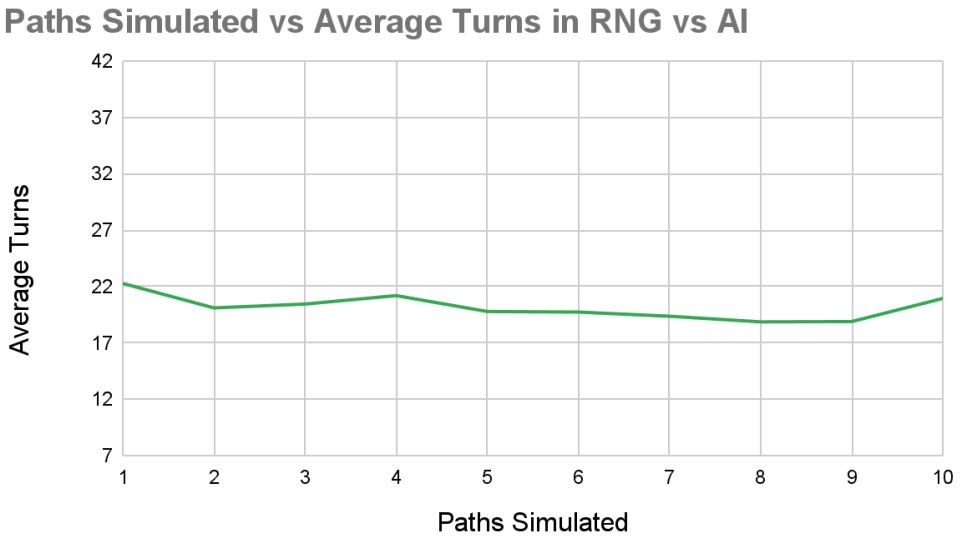
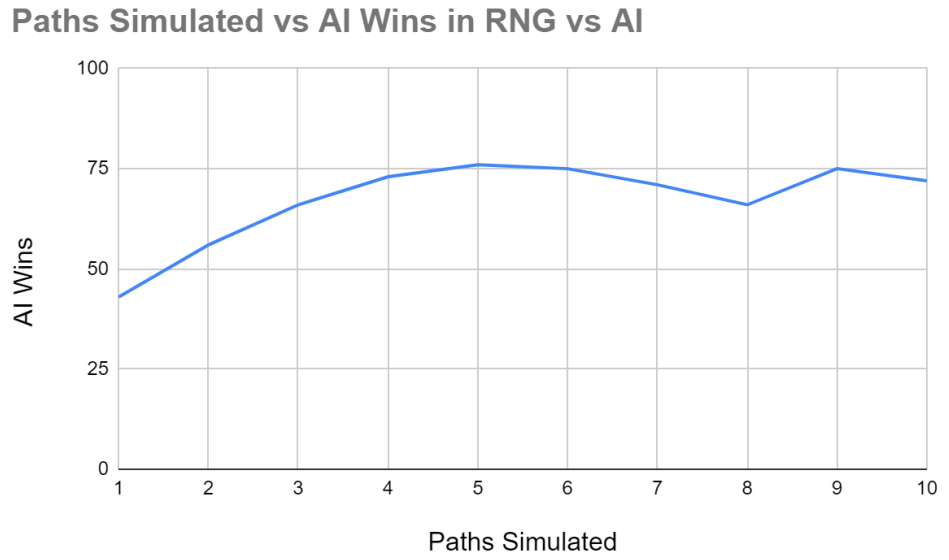
Graphs for RNG vs AI (RNG Player Goes First)







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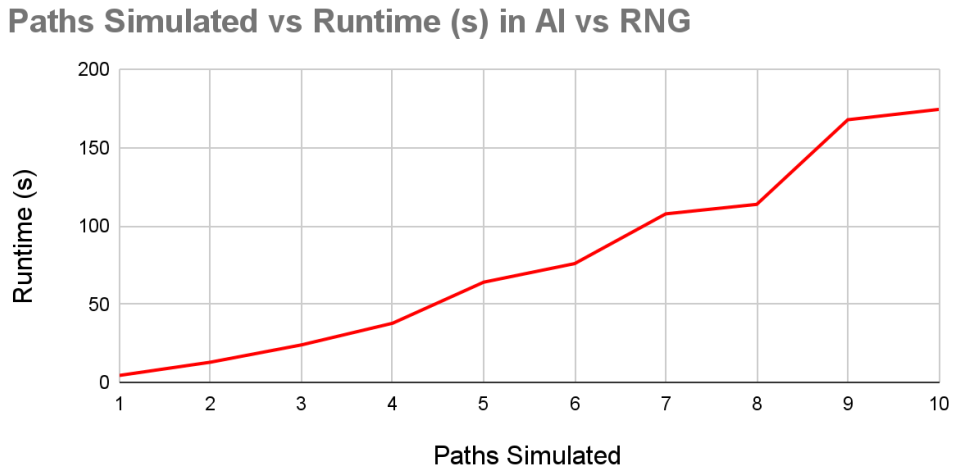
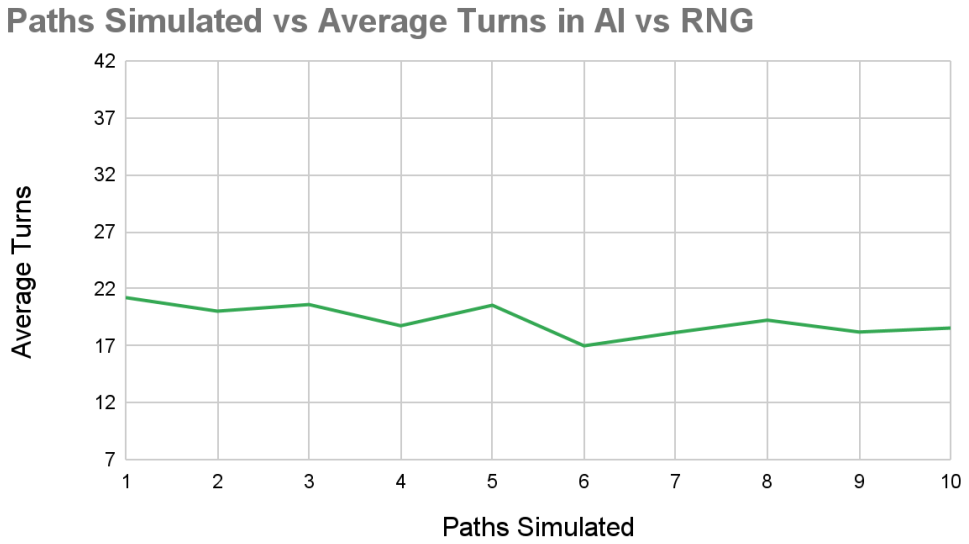
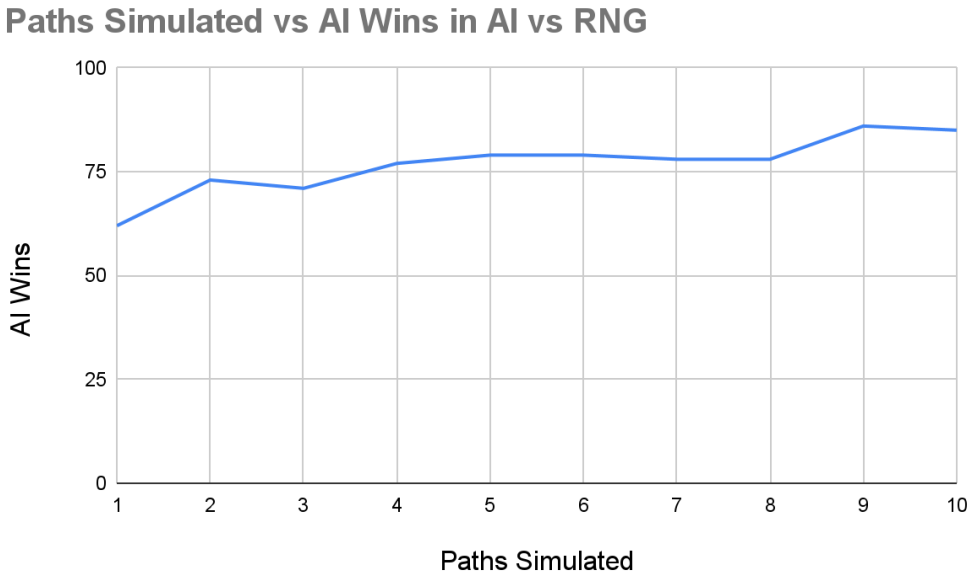
Graphs for AI vs RNG (AI Player Goes First)







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Reflection Questions

1. Describe the effect the number of paths sampled the AI performs on the:
    a. Runtime
        i. The runtime of the 100 games appeared to grow at a slow exponential rate as the AI performed more simulations of the connect four game. This happened for both cases where the AI went first and when the RNG player went first. However, it's important to note that if the RNG player goes first, the runtimes are about 10 times quicker than the runs where the AI player goes first.
    b. Average amount of turns
        i. For both cases (RNG player going first and AI player going first), the average amount of turns played for 100 games seemed relatively stable with a slight drop more towards the end with more paths simulated. For our graphs, we noted that at least 7 turns need to be played until any player can win the game; at most 42 turns can be played because connect four is a game defined by a 6 row and 7 column grid. Every value for the average turns were between 17 and 22 turns.
    c. Number of wins for the AI
        i. For both cases, the amount of sample paths increased the amount of wins the AI had up to a certain point. After around a strength factor of 5-6 simulated paths, the amount of wins the AI achieved started stagnating around a 75% win rate. It's important to note that when the AI goes first, they on average achieved more wins compared to when it went second. This is because in connect four, the first player always has the advantage when it comes to playing the game, especially when they play perfectly by starting a piece in the center of the board.
2. Describe what combination of parameters are best believed to offer the best tradeoff between paths sampled (strength) and runtime
    a. Based on our results, we think a strength of around five paths is the best tradeoff for the amount of runtime and still achieving a consistent amount of wins. When adding more depth to the AI, the amount of wins didn't substantially increase after the 4-6 paths simulated range for both cases. It's also important to keep in mind that all of these results are based on 100 games being played. The only people who would practically play connect four against some AI is if they're on an international plane and it has connect four as an onboard tablet game (even then, they likely would only play one or two games, not 100).
3. Describe what you would like to explore in the future to improve your intelligence. Possible approaches include smarter search algorithms, more sophisticated scoring methods, and ways to estimate the probability that the other player will make each move to improve the accuracy of the scores. Choose two approaches, describe them, explain how you would go about implementing them, and explain why you think those approaches would improve the strength or run time of the AI engine.
    a. According to the internet, connect four is already a solved game. It would be interesting to research the already existing and created winning strategies and code them in for an alternative AI; we could then pit our two AIs against each other and see how Monte Carlo Tree AI fairs against an AI that knows the perfect algorithms

to win. This could help us measure how effective the Monte Carlo Tree strategy is too.

b. For finding the win ratio for 100 games, it would be interesting to count stalemates as half a win instead of not being a win at all. Maybe we would see a larger skew in our win curves towards the ends with higher path simulated values.