COMP20003 - Algorithms and Data Structures

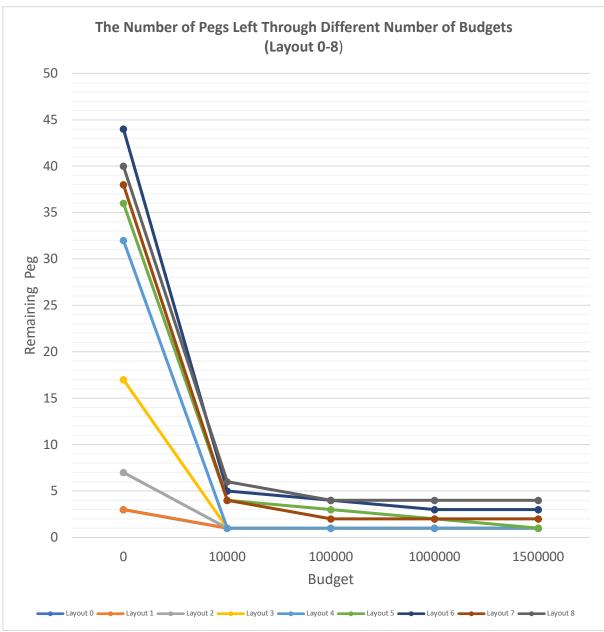
Assignment 3- Experimentation

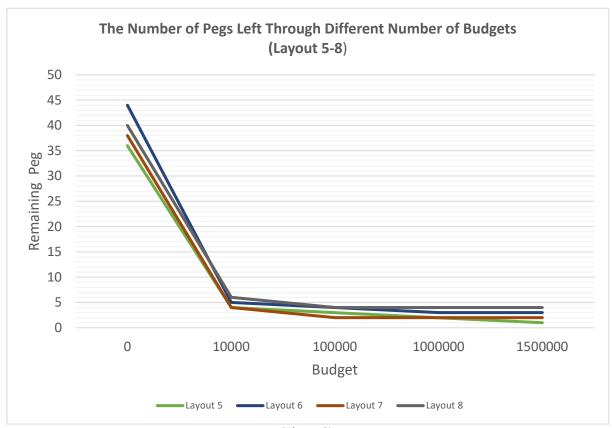
Introduction

The experimentation is going to discuss the performance of Al algorithm on playing Peg Solitaire. The algorithm is based on Depth First Search (DFS) strategy which is using a stack to decide explored nodes and a hash table to avoid duplicate cases, eventually it is expected to find out the best solution with limited budgets. The following table contains the important data including the number of pegs left, generated nodes, expanded nodes, expanded/second, total execution time and ratio of generated/expanded nodes for each layout and each max budget of 10K, 100K, 1M, 1.5M.

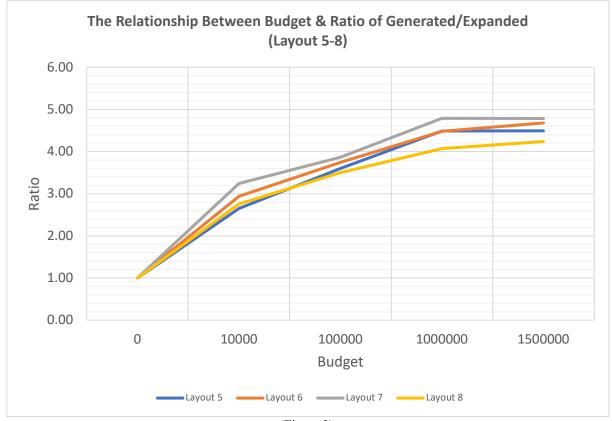
Number of Pags left	Layout 0 (3 pegs)							
1,000,000	Results	Number of Pegs left	Generated Nodes	Expanded Nodes	Expanded/Second	Total Execution Time (seconds)	*Ratio of Generated/Expanded	
1,000,000 1 2 2 2 49 0.04338 1.000000 1,050,000 1 2 2 2 66 0.04338 1.000000 1,050,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 3 3 3 71 0.042198 1.000000 1,000,000 1 8 7 1.04218 1.000000 1,000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 8 7 1.052 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 5.000 1.000,000 1 1.052 3.541 1.000 1.000,000 1 1.052 3.000,000 1 1.052 3.000,000 1 1.052 3.000,000 1 1.052 3.000,000 1 1.052 3	10,000	1		2	44	0.045158	1.000000	
1,50,000								
Layout 1 (4 pegs)								
Number of Pegs left	1,500,000	1	2	2	46	0.043138	1.000000	
Number of Pegs left	Lunder 11-2							
10,000	Results	Number of Deep left	Consusted Nades			Tatal Sussition Time (accords)	*Patie of Commented / Francisco	
1,00,000		Number of Pegs left		Expanded Nodes				
1,000,000		1		3				
1,500,000								
Layout 2 (7 pegs)								
Number of Pegs left Generated Nodes Expanded Nodes Expanded/Second Total Execution Time (seconds) *Ratio of Generated/Expanded 10,000 1 8 7 156 0.041965 1.142857 1.000,000 1 8 7 157 0.044426 1.142857 1.000,000 1 8 7 157 0.044426 1.142857 1.000,000 1 8 7 157 0.044426 1.142857 1.000,000 1 8 7 162 0.040234 1.142857 1.000,000 1 1.000 Expanded Nodes Expanded/Second Total Execution Time (seconds) *Ratio of Generated/Expanded 1.0000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 1.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.065 2.1,500 0.000,000 1 2.418 1.005 2.1,500 0.000,000 1 2.418 1.005 2.1,500 0.000,000 1 2.418 1.005 2.1,500 0.000,000 1 2.418 1.000,000 2.1,500 0.000,000 1 2.418 1.000,000 2.1,500 0.000,000 1 2.418 1.000,000 2.1,500 0.000,000 2.1,500 0.000,000 2.1,500 0.000,000 2.1,500 0.000,000 2.1,500 0.000,000 2.1,50	, , ,							
10,000								
100,000	Results	Number of Pegs left	Generated Nodes	Expanded Nodes	Expanded/Second	Total Execution Time (seconds)	*Ratio of Generated/Expanded	
1,000,000	10,000	1	8	7	166	0.041963	1.142857	
1,500,000								
Layout 3 (17 pegs)								
Number of Pegs left	1,500,000	1	8	7	162	0.042999	1.142857	
Number of Pegs left								
10,000	Results							
10,000								
1,000,000								
Layout 4 (32 pegs) Layout 4 (32 pegs) Number of Pegs left Generated Nodes Expanded Nodes Expande					·			
Layout 4 (32 pegs)								
Layout 5 (36 pegs) Number of Pegs left Generated Nodes Expanded Nodes Expanded/Second Total Execution Time (seconds) *Ratio of Generated/Expanded 10,000 1 2,418 1,065 21,012 0.055683 2.270423 1,000,000 1 2,418 1,065 21,852 0.038736 2.270423 1,500,000 1 2,418 1,065 21,852 0.038736 2.270423 1,500,000 1 2,418 1,065 21,852 0.038736 2.270423 1,500,000 1 2,418 1,065 21,925 0.048574 2.270423 1,500,000 1 2,418 1,065 21,925 0.048574 2.270423 1,500,000 4 26,495 10,000 92,208 0.10845 2.649500 100,000 3 359,818 100,000 213,799 0.467729 3.598180 1,000,000 2 4,488,464 1,000,000 259,411 3.358433 4.488464 1,500,000 2 4,488,464 1,000,000 259,411 3.358433 4.488464 1,500,000 5 29,368 1,000,000 29,229 0.101802 2.936800 1,000,000 3 37,4378 100,000 20,4160 0.488811 3.743780 1,000,000 3 4,481,233 1,000,000 274,582 3.641888 4.481233 1,000,000 274,582 3.641888 4.481233 1,500,000 3 4,481,233 1,000,000 274,582 3.641888 4.481233 1,500,000 3 4,781,233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 274,582 3.641888 4.481233 1,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 2 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,500,000 3,5	1,300,000	1	10,202	3,341	30,401	0.070173	2.503700	
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Number of Pegs left	1,300,000	-	4,050,005	1,030,273	277,000	3.33307	4.433003	
Number of Pegs left	Layout 6 (44 pegs)							
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1,500,000 3 7,020,668 1,500,000 274,564 5.463202 4.680445								
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Number of Pegs left	1,500,000	3	7,020,668	1,500,000	274,564	5.463202	4.680445	
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Budgets Number of Pegs left Generated Nodes Expanded Nodes Expanded/Second Total Execution Time (seconds) *Ratio of Generated/Expanded 10,000 6 27,562 10,000 97,988 0.102053 2.756200 100,000 4 349,921 100,000 212,286 0.471062 3.499210 1,000,000 4 4,073,028 1,000,000 286,336 3.492394 4.073028 1,500,000 4 6,861,454 1,500,000 219,024 6.848549 4.240969	1,300,000		7,173,304	1,300,000	241,030	0.20/0/9	4.782550	
Budgets Number of Pegs left Generated Nodes Expanded Nodes Expanded/Second Total Execution Time (seconds) *Ratio of Generated/Expanded 10,000 6 27,562 10,000 97,988 0.102053 2.756200 100,000 4 349,921 100,000 212,286 0.471062 3.499210 1,000,000 4 4,073,028 1,000,000 286,336 3.492394 4.073028 1,500,000 4 6,861,454 1,500,000 219,024 6.848549 4.240969				L	ayout 8 (40 pegs)			
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1,000,000 4 4,073,028 1,000,000 286,336 3.492394 4.073028 1,500,000 4 6,361,454 1,500,000 219,024 6.848549 4.240969								
(Table 1)	1,500,000	4	6,361,454			6.848549	4.240969	
					(Table 1)			

To be clearer, the following plots show the number of pegs left through different number of budgets, and the relationship between budget and ratio of generated nodes to expanded nodes.





(Figure 2)



(Figure 3)

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Analysis

The experimental results reveal that the question which has less than thirty initial pegs can be easily solve by under 10K expanded nodes. However, although the difference of initial pegs between layout 4 and layout 5 is four pegs, the layout 5 required nearly 1,090,000 more budgets than layout 4 to find the solution. Also, layout 8 initially has less pegs than layout 6, and yet layout 6 left less pegs at the end of 1.5M budgets. Therefore, besides the difference of number, the shape of board may also influence the performance on the algorithm. From Figure 1, we can see that most of the layouts can be figured out the solution which has under five remaining pegs by using 10K budgets. It indicates that the algorithm can easily eliminate the number of pegs quickly. However, to get a better solution is harder and harder through the solving process. It can be seen more clearly in Figure 2 which only plots the last four layouts. The solution quality is lower as the budgets increasing. It means that to find out the best solution, the cost of budgets is very expensive and maybe not efficient. The reason might be that DFS strategy need to traverse back and discover other paths. Without any optimization, the hash table would keep recording the similar rotationally board which is no need to be test further since they are in the same shape, and it would increase the explored nodes which is going to increase the demand of budget as well. To estimate the duplicate probability, the ratio of generated nodes to expanded nodes is increasing through the growth of budgets (see Figure 3). Since a proper (unseen) nodes would require more generated nodes, the trend highlights that more duplicate states would be created as the DFS is attempting more possibilities. On the other hand, if an optimization can be made for reducing duplicate cases (including rotational and symmetrical), the efficiency of finding the best solution might be higher.

Conclusion

Overall, the AI algorithm using Depth First Search strategy can quickly reduce the remaining pegs in 10K budgets. Yet, to find out the best solution (one peg left condition), it requires far more budgets than expected. Thus, there might be a dilemma of giving up certain accuracy and saving some budgets eventually. Additionally, the frequency of duplicate board is increasing as the increment of budgets. To optimize the programming, it can be upgraded by classifying rotational and symmetrical boards as a seen state. In this way, it would push only the necessary generated nodes into the stack without duplicate boards and it would make the programming to use the limited budgets more efficiently.