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Foundations of AI

Assignment 2: Answers

Algorithm	Time Complexity	Space Complexity	Complete?	Optimal?
BFS	O(b^d+1)	O(b^d+1)	Yes, guaranteed to find a solution	Yes, assuming that all actions have uniform cost
UCS	O(b^d)	O(b^d)	Yes, guaranteed to find a solution	Yes, will always expand to the node with the lowest total path cost
DFS	O(b^n)	O(bn)	Yes, if on a finite graph	No, there is no guarantee that the first solution found will be the best
DLS	O(bd)	O(bd)	Yes, only if solution is above depth level	No, if the problem has more than one solution
IDS	O(b^d)	O(b^d)	Yes, if on a finite graph	Yes, if the edge costs are the same
A*	O(b^d)	O(b^d)	Yes	Yes, when our heuristic is admissible

Total States
Before Tool Functions:
BFS: 9
DFS: 13
DLS: 16

After Tool Functions:
BFS: 16

DFS: 16
DLS: 16

After Problem Decomposition:
BFS: 11
DFS: 11
DLS: 11

A*: 32
UCS: 32

Question 4. Responses

a) What were the engineering advances that led to Deep Blue's success? Which of them can be transferred to other problems, and which are specific to chess?

Deep Blue's success in defeating Garry Kasparov stemmed from advances in engineering, including parallel processing, alpha-beta pruning for efficient move evaluation, and chess-specific heuristics. Parallel computing and search optimization techniques, such as alpha-beta pruning, apply to many areas, such as AI, game theory, and decision-making problems. However, some features, like Deep Blue's pre-programmed chess knowledge, were highly specialized for chess and could not transfer that knowledge to other domains. The balance between brute-force computation and chess expertise was crucial to Deep Blue's design.

b) AlphaZero is compared to a number of modern game-playing programs, such as StockFish, which work similarly to Deep Blue. The paper shows that AlphaZero is able to defeat StockFish even when it is given only 1/100 of the computing time. Why is that? Please frame your answer in terms of search and the number of nodes evaluated.

AlphaZero can defeat programs like StockFish because it uses a more efficient search method combined with deep learning. StockFish, like Deep Blue, relies on brute-force search techniques, evaluating millions of nodes per second through alpha-beta pruning and heuristics. In contrast, AlphaZero uses a Monte Carlo Tree Search that predicts both move probabilities and position evaluations. This allows AlphaZero to evaluate fewer nodes, focusing only on positions based on learned patterns rather than searching through every possibility. As a result, AlphaZero achieves better outcomes by evaluating fewer but higher-quality nodes, making its search process much more efficient.