CS2109s - Tutorial 3

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Sep 13, 2023
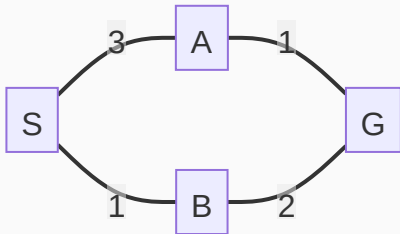
Important admin

No admin annoucements today.

Tidbits from tutorials

1. GBFS with a consistent heuristic is it optimal? - In this case h^* used, but still not optimal SAG instead of SBG.


```
S(3)
A(1) B(2)
G(0) B(2)
SAG
```

$h(S) = 3, h(A) = 1, h(B) = 2, h(G) = 0$

Problem Set 2

1. Question 1.2 - A*Star algorithm
   1.1 Check if node is visited
   1.2 PQ not updated correctly when encountering a path to a child node with a lower cost.
2. Question 2.2 - TSP Goal node cannot be known explictly

Task 1.3 - Why heuristic is consistent and admissible [Liang Wenzhong TG4].

Let the shape of the 2D Rubik cube be `(R, C)`. Denote `M = max(R, C)`.

My heuristic is: `h(n) = sum_of_misplaced_pieces(n) / M`

Admissibility

Heuristic is admissible since in the original puzzle, each move will correct at most `M` number of pieces, and the heuristic is saying each move is the best move possible (i.e. correct `M` number of pieces), hence this heuristic can never be larger than the actual number of moves. $\Rightarrow$ `h(n) <= h*(n)`

Consistency

Let n be a state in the puzzle, and n' be the direct successor of n (i.e. the children of n) Denote G to be the goal state.

Let x be the number of misplaced piece in state n, and M as described above. Then we deduce that h(n) = x / M

Notice that n' can have at least x – M misplaced pieces. Since every move can at most put M pieces into the right place.

Thus, h(n') >= (x – M) / M = x / M – 1

Also, for this puzzle c(n, a, n') = 1 given that a is a valid move that move n to n', as each move of the Rubik cube have uniform cost.

=> c(n, a, n') + h(n') >= 1 + (x / M – 1) = x / M

=> h(n) <= c(n, a, n') + h(n')

Thus, by the definition of consistent, it is shown that h(n) is consistent, and hence also admissible.

Question 1

Tic-Tac-Toe - Use the minimax to determine the first move of the player.

$$Eval(n) = P(n) - O(n), \quad \text{where } P(n), O(n) \text{ are the no. of winning lines}$$

Recap
1. What is the MINIMAX algorithm? Why is it used?
2. What are the ingredients needed to setup a minimax problem?
3. What is the impact of choosing min/max in our computation?
4. When was MINIMAX famously used in AI?

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- Actors: Min/Max, Leaf Cost
- IBM Deep Blue versus Garry Kasparov in Chess.
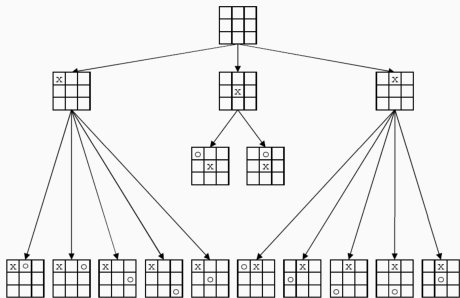
Question 1a

Figure 1: First move 2-ply deep search space
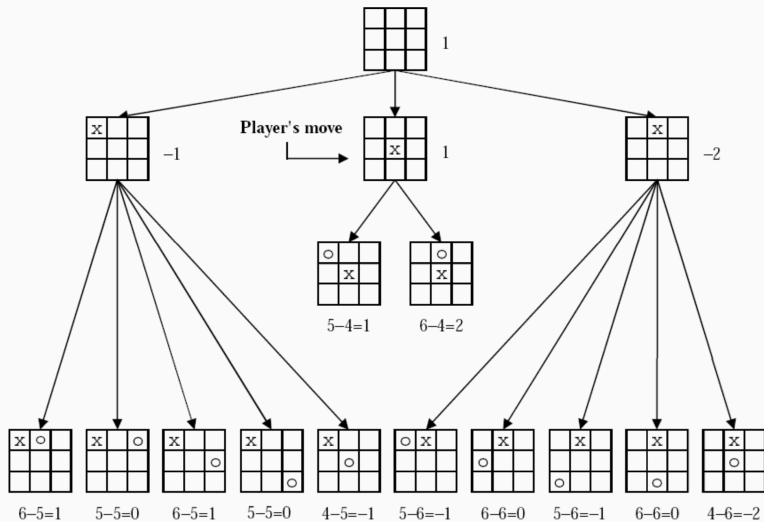
Answer 1a

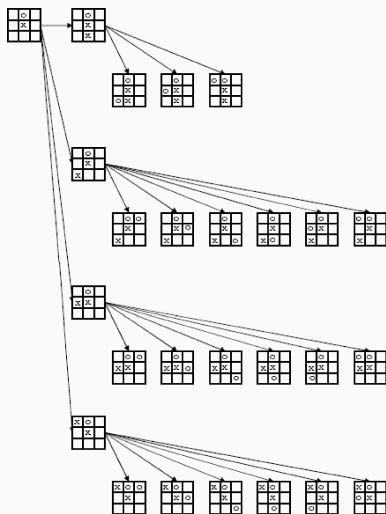**Figure 2:** First move 2-ply deep search space

7

Question 1b

Figure 3: Second move 2-ply deep search space solution

Answer 1b
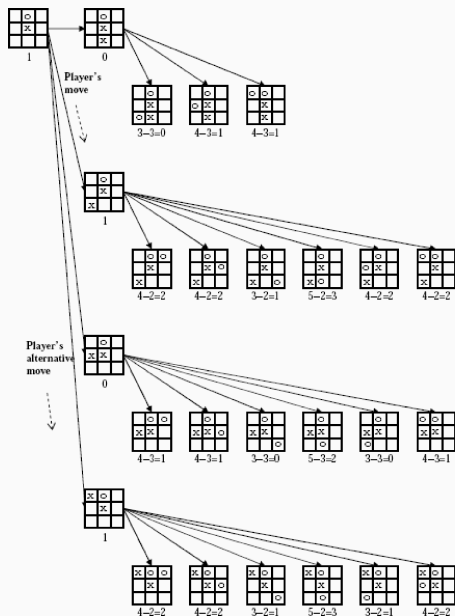
Question 2 [G]

Run through the α-β:

a. Right to Left
b. Left to Right

Then determine if the effectiveness of pruning depends on iteration order.

Figure 5: Alpha-Beta Tree

Recap

1. What does α-β do?
2. What kind of efficiency do you gain?
3. What is deep cutoff?

Question 2 [G]

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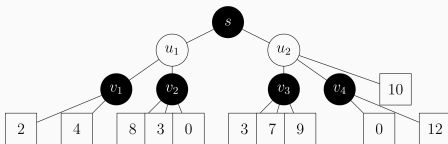Then determine if the effectiveness of pruning depends on iteration order.
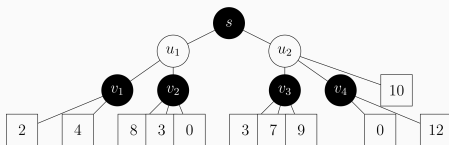

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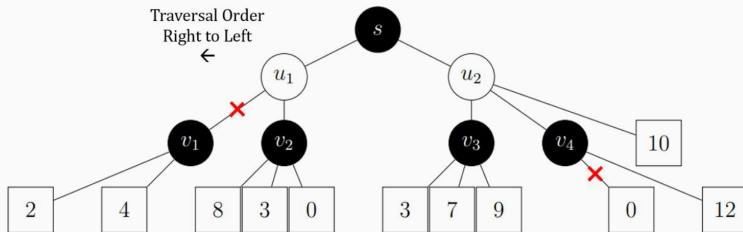Save on static evaluation and move generation.
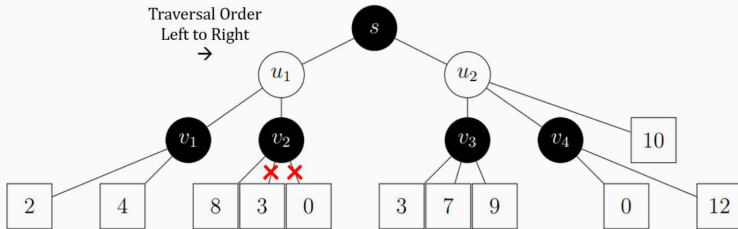
Answer

Figure 6: Right to left

Figure 7: Left to right

Question 3

Nonogram, aka Paint by Numbers, is a puzzle where cells are colored or left blank according to the numbers at the side of the grid.

Figure 8: Inital

Figure 9: Solved

Question 3a [G]

Having learnt both informed search and local search, you think that local search is more suitable for this problem. Give 2 possible reasons why informed search might be a bad idea.

Recap

1. What are the ingredients needed for informed search?
2. What are the ingredients needed for local search?
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Local Search (Goal): Inital state, Transition, Heuristic/Stopping criteria

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Answer 3a

- We are only interested in the final solution.
- Search space is large $O(2^{n \times n})$ for a $n \times n$ grid.
- May not be solvable? In that case we can get a config that minimize violations.

Question 3b / 3c / 3d / 3e [G]
Find a formulation for **Local Search**.

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Answer 3b / 3c / 3d / 3e
$n \times n$ boolean matrix, where each element is either true (if the corresponding cell is colored) or false (if the corresponding cell is not colored).

- **Inital state** is an $n \times n$ boolean matrix with every row having random permutations of boolean vector satisfying row constraints, while the rest of the entries are set to false.
- **Transition**: we can pick a random row and generate the list of neighbours with the corresponding row permuted satisfying row constraints.
- **Heuristic/Stopping criteria**: number of instances where the constraints on the column configurations are violated.

Question 3f [G]

Local search is susceptible to local minimas. Describe how you can modify your solution to combat this.

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Answer 3f
- Introduce random restarts by repeating local search from a random initial state
- Simulated annealing search to accept a possibly bad state with a probability that decays over time
- beam search to perform k hill-climbing searches in parallel.

Question 4 [G]

In order for node B to NOT be pruned, what values can node A take on?

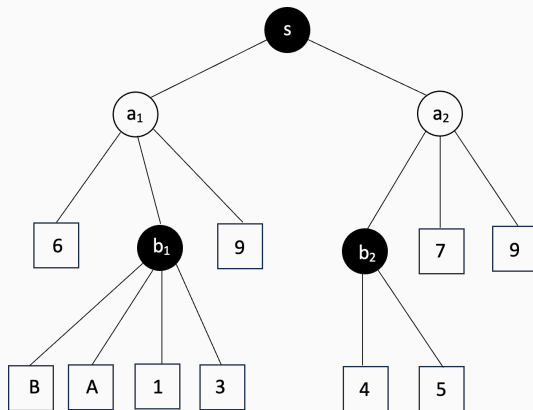**Figure 10:** Find A so the B is not pruned.

```
< S -inf inf
        < a2 -inf inf
        > a2 -inf 9
        < a2 -inf 9
        > a2 -inf 7
        < a2 -inf 7
                < b2 -inf 7
                > b2 5 7
                < b2 5 7
                > b2 5 7
        > a2 -inf 5
> S 5 inf
```

```
< S 5 inf
        < a1 5 inf
        > a1 5 9
        < a1 5 9
                < b1 5 9
                > b1 5 9
                < b1 5 9
                > b1 5 9
                < b1 5 9
                > b1 Pruned val >= beta: 9 >= 9
        > a1 5 9
        < a1 5 9
        > a1 5 6
> S 6 inf
```

Bonus Qn

To help you further your understanding, not compulsory; Work for Snack/EXP!

Tasks

1. Trace Manually/Use code Figure 11 to see the full capability.
    1.1 Some code implemented in https://github.com/eric-vader/CS2109s-2324s1-bonus
2. How can we benefit from α-β's efficiency?
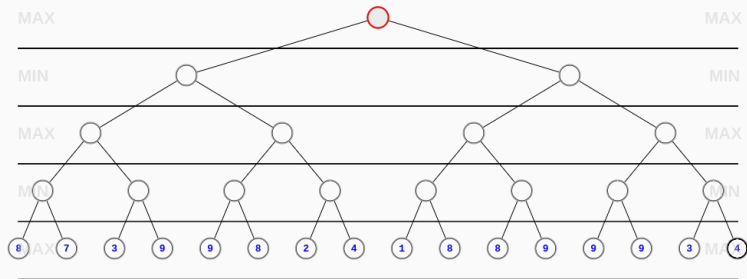
Figure 11: Alpha-Beta Example (Credit MIT)

Buddy Attendance Taking

Take Attendance for your buddy: https://forms.gle/Ckkq639TNwWEx3NT6

1. Random checks will be conducted - `python ../checks.py TG0`

Figure 12: Buddy Attendance