

Performance comparison between minimax and alpha-beta pruning in our project

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May 20, 2023

1 Introduction

We show two Connect-N games with different configurations. Each game was played two times: one with the computer playing using the minimax algorithm and the other with the computer playing using the alpha-beta pruning algorithm. The same moves were made both times.

2 Games

The following sections show textual statistics about the moves made in each game and scatter charts showing the time taken to perform each move.

In the textual statistics block, the first line is the human's move, the second is a pair consisting of the computer's move and the heuristic estimation for this move and the third is the performance statistics

2.1 Game 1

8x8 board, winning factor 5, max-ply 3, human red, human starts

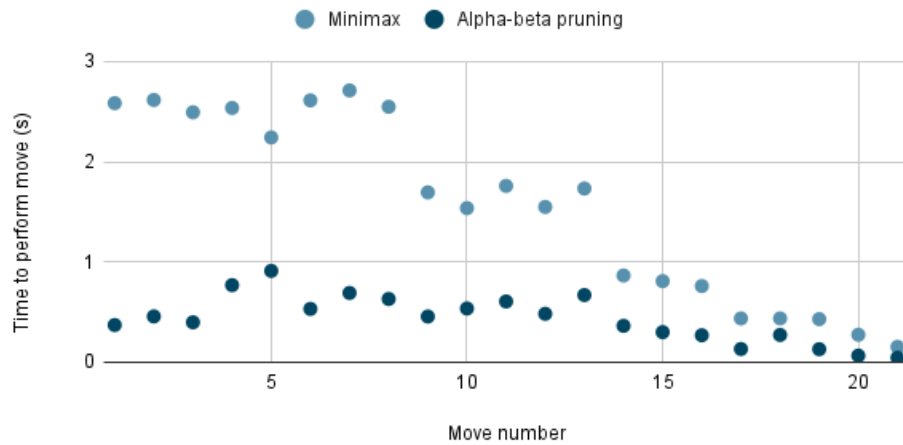


Figure 1: Game 1

Minimax textual statistics:

```
3
[3,12]
% 42,280,716 inferences, 2.582 CPU in 2.584 seconds
2
[3,20]
% 42,519,134 inferences, 2.614 CPU in 2.616 seconds
4
[1,14]
% 40,517,478 inferences, 2.492 CPU in 2.493 seconds
3
[3,21]
% 41,944,727 inferences, 2.535 CPU in 2.536 seconds
6
[5,26]
% 35,131,146 inferences, 2.240 CPU in 2.242 seconds
5
[3,31]
% 43,228,206 inferences, 2.611 CPU in 2.612 seconds
1
[5,35]
```

% 43,201,541 inferences, 2.709 CPU in 2.711 seconds
0
[3,40]
% 43,548,639 inferences, 2.547 CPU in 2.548 seconds
3
[1,42]
% 26,017,156 inferences, 1.693 CPU in 1.694 seconds
1
[1,42]
% 26,087,886 inferences, 1.537 CPU in 1.537 seconds
5
[5,45]
% 26,167,773 inferences, 1.758 CPU in 1.759 seconds
7
[5,48]
% 26,390,374 inferences, 1.548 CPU in 1.549 seconds
7
[5,51]
% 26,298,711 inferences, 1.732 CPU in 1.733 seconds
5
[1,54]
% 14,576,416 inferences, 0.863 CPU in 0.865 seconds
1
[7,51]
% 12,737,689 inferences, 0.808 CPU in 0.809 seconds
7
[0,52]
% 12,775,972 inferences, 0.760 CPU in 0.760 seconds
1
[0,55]
% 7,210,814 inferences, 0.437 CPU in 0.437 seconds
0
[2,51]
% 7,223,652 inferences, 0.437 CPU in 0.437 seconds
7
[4,54]
% 7,087,868 inferences, 0.430 CPU in 0.430 seconds
4
[2,1000000]
% 4,429,841 inferences, 0.274 CPU in 0.274 seconds
2
[4,1000000]
% 2,362,921 inferences, 0.153 CPU in 0.153 seconds

Alpha-beta pruning textual statistics:

```
3
[3,12]
% 5,716,313 inferences, 0.371 CPU in 0.371 seconds
2
[3,20]
% 7,166,306 inferences, 0.457 CPU in 0.457 seconds
4
[1,14]
% 6,137,486 inferences, 0.398 CPU in 0.398 seconds
3
[3,21]
% 12,046,441 inferences, 0.769 CPU in 0.769 seconds
6
[5,26]
% 14,533,102 inferences, 0.910 CPU in 0.911 seconds
5
[3,31]
% 8,748,823 inferences, 0.531 CPU in 0.532 seconds
1
[5,35]
% 10,596,873 inferences, 0.691 CPU in 0.691 seconds
0
[3,40]
% 10,254,576 inferences, 0.631 CPU in 0.631 seconds
3
[1,42]
% 7,135,330 inferences, 0.455 CPU in 0.456 seconds
1
[1,42]
% 7,452,837 inferences, 0.536 CPU in 0.536 seconds
5
[5,45]
% 10,051,487 inferences, 0.606 CPU in 0.606 seconds
7
[5,48]
% 7,972,577 inferences, 0.482 CPU in 0.483 seconds
7
[5,51]
% 9,303,089 inferences, 0.670 CPU in 0.670 seconds
5
[1,54]
% 5,924,528 inferences, 0.363 CPU in 0.363 seconds
```

```

1
[7,51]
% 4,856,939 inferences, 0.300 CPU in 0.300 seconds
7
[0,52]
% 4,255,380 inferences, 0.269 CPU in 0.269 seconds
1
[0,55]
% 1,995,347 inferences, 0.132 CPU in 0.132 seconds
0
[2,51]
% 2,682,877 inferences, 0.272 CPU in 0.272 seconds
7
[4,54]
% 1,928,964 inferences, 0.130 CPU in 0.130 seconds
4
[2,1000000]
% 839,921 inferences, 0.066 CPU in 0.066 seconds
2
[4,1000000]
% 498,434 inferences, 0.045 CPU in 0.045 seconds

```

2.2 Game 2

6x7 board, winning factor 4, max-ply 4, human blue, computer starts

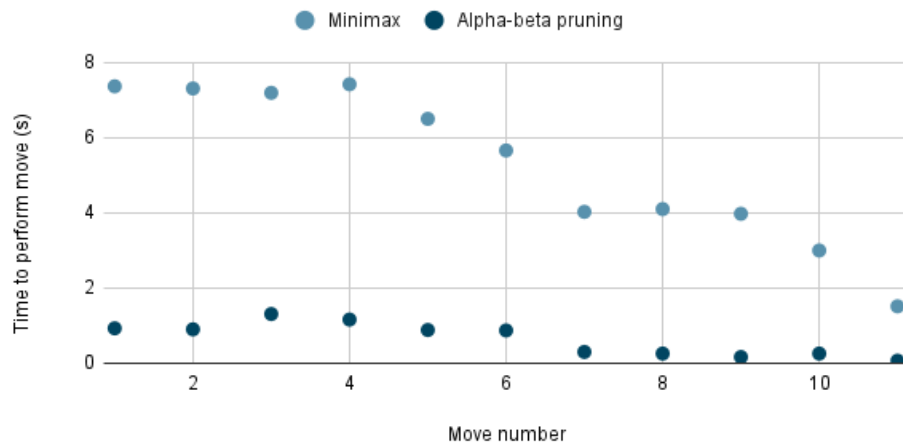


Figure 2: Game 2

Minimax textual statistics

[3,20]
% 117,311,107 inferences, 7.362 CPU in 7.366 seconds
4
[3,22]
% 116,841,765 inferences, 7.302 CPU in 7.308 seconds
2
[3,26]
% 114,222,392 inferences, 7.188 CPU in 7.192 seconds
3
[3,27]
% 116,874,628 inferences, 7.416 CPU in 7.420 seconds
0
[2,31]
% 102,368,740 inferences, 6.496 CPU in 6.500 seconds
2
[4,35]
% 89,958,939 inferences, 5.656 CPU in 5.659 seconds
4
[0,1000000]
% 67,335,004 inferences, 4.023 CPU in 4.026 seconds
6
[0,1000000]
% 62,683,419 inferences, 4.098 CPU in 4.100 seconds
2
[0,1000000]
% 60,393,246 inferences, 3.973 CPU in 3.975 seconds
0
[4,1000000]
% 50,379,805 inferences, 2.997 CPU in 2.999 seconds
2
[1,1000000]
% 23,534,881 inferences, 1.513 CPU in 1.514 seconds

Alpha-beta pruning textual statistics

[3,20]
% 14,071,311 inferences, 0.928 CPU in 0.929 seconds
4
[3,22]
% 14,124,223 inferences, 0.900 CPU in 0.902 seconds
2
[3,26]
% 20,698,596 inferences, 1.308 CPU in 1.309 seconds

```
3
[3,27]
% 17,067,110 inferences, 1.160 CPU in 1.161 seconds
0
[2,31]
% 14,221,267 inferences, 0.883 CPU in 0.884 seconds
2
[4,35]
% 12,329,467 inferences, 0.871 CPU in 0.872 seconds
4
[0,1000000]
% 4,751,373 inferences, 0.299 CPU in 0.300 seconds
6
[0,1000000]
% 4,015,472 inferences, 0.257 CPU in 0.257 seconds
2
[0,1000000]
% 2,491,188 inferences, 0.165 CPU in 0.165 seconds
0
[4,1000000]
% 3,954,875 inferences, 0.257 CPU in 0.257 seconds
2
[1,1000000]
% 823,608 inferences, 0.067 CPU in 0.067 seconds
```