Universitat de Barcelona

Report Artificial Intelligence

Practical II - Adversial Games

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Introduction

In this second assignment, we're provided with a specific initial board configuration containing two black pieces: a black king at [0,5] and a black rook at [0,7], and two white pieces: a king at [7,5] and a rook at [7,0].
To complete this assignment, we're tasked with determining the possible outcomes (win for white, win for black, or a draw) using three different algorithms: Minimax, Alpha-Beta Pruning, or Expectimax.

Questions

1a) Once implemented, run the same game a few times. How often do whites win? Provide a justification for that.

Whites win all times.

Depth = 4 for both colors:

```
*********************************
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
*********************************
JAQUE MATE, GANAN LAS  BLANCAS
```

Whites wins all time with depth = 4 for each colors, and this generates more possible movement, and he can select the first and the best movement.

2) Plot the percentage of white wins over the total for each depth value. Is the result symmetric. Why is that?

Depth = 3 for both colors:

```
*********************************
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   | R |   |   |   |   |   |   |
| K |   | K |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
*********************************
JAQUE MATE, GANAN LAS  NEGRAS
```

DepthWhite = 4, DepthBlack = 3:

```
K moved.
->piece initial state  [2, 3, 6]
->piece to state  [2, 2, 6]
*********************************
|   | K |   |   |   |   |   |   |
|   |   |   |   |   |   |   | R |
|   |   | K |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
*********************************
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```

DepthWhite = 3, DepthBlack = 4:

```
*********************************
|   |   |   |   |   |   |   | R |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   | K |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
| R |   |   |   |   |   |   |   |
*********************************
JUEGO EN TABLAS
```

Depth = 4 for both colors:

```
*********************************
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
*********************************
JAQUE MATE, GANAN LAS  BLANCAS
```

In the case of a depth of 3 for each side, we can see that Black wins because the move chosen by White, in this instance moving the king, has given an advantage to the black pieces. However, when it's depth 4 for White and depth 3 for Black, White wins, and from this point on, in all scenarios, White will win. But as the depth increases, the search space expands, leading to longer execution times. That's why we haven't experimented with higher depths.

The White pieces have a 66.6% win rate for each depth out of the total calculated wins. However, within each depth, the victories remain constant because there's no randomness in the heuristic. This leads to an unchanging sequence of moves for each depth, as the calculations consistently lead to the same best path being chosen

3) Implement the alfa-beta pruning for the blacks only, whites still play with minimax. Using an equal depth of 4, run the simulation three times. Who is the best of three? Why is that?

Run 1:

```
K moved.
->piece initial state  [4, 1, 6]
->piece to state  [3, 0, 6]
*********************************
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
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JAQUE MATE, GANAN LAS  BLANCAS
PS C:\Users\mohsi\Documents\GitHub\IA\practica2studs>
```
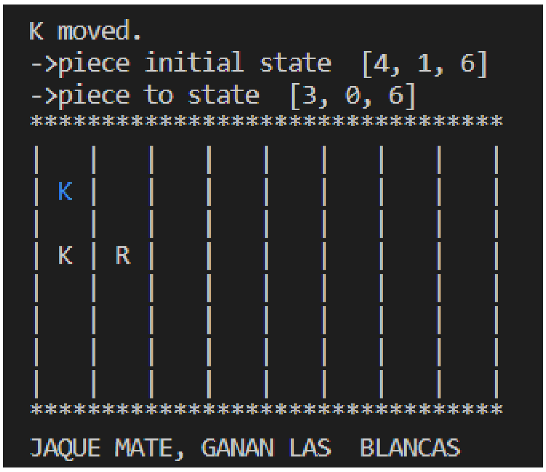

Run 2:



Run 3:

The best of three in this case are always the whites which are using minimax although the blacks are using alpha-beta which is much faster in terms of execution time then minimax but since whites start first, the advantage goes to them and for that reason, in all three runs, whites win.

4) Plot the proportion of wins for whites and blacks. Comment on the result.

Depth = 1:

```
R moved.
->piece initial state  [6, 1, 8]
->piece to state  [7, 1, 8]
*********************************
|   |   |   |   | K |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
*********************************
JUEGO EN TABLAS
```

Depth = 2:

```
R moved.
->piece initial state  [1, 7, 2]
->piece to state  [0, 7, 2]
*********************************
| K |   |   |   |   |   |   | R |
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
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```

Depth = 3:

```
K moved.
->piece initial state  [5, 2, 12]
->piece to state  [6, 2, 12]
*********************************
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   | R |   |   |   |   |   |   |
| K |   | K |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
*********************************
JAQUE MATE, GANAN LAS  NEGRAS
PS C:\Users\mohsi\Documents\GitHub\IA\practica2studs>
```

Depth = 4:

```
K moved.
->piece initial state  [4, 1, 6]
->piece to state  [3, 0, 6]
*********************************
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
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JAQUE MATE, GANAN LAS  BLANCAS
```

The results are the same with Minimax, except that the execution speed is slower due to unnecessary checks that are skipped. In a game of such magnitude, this optimization makes it more efficient

5) Implement the expectimax algorithm for whites and blacks. Whites play expectimax, blacks alfa-beta pruning. Run three simulations each and plot the proportion of wins for whites/blacks. Who wins the most. Why is that?

The results are the same with Alpha-Beta Pruning except that the execution speed is slower due the unnecessary checks and we aren't watching all successors in case of expectimax min.

```
|   |   |   |   |   |   |   |   |
*********************************
K moved.
->piece initial state  [4, 1, 6]
->piece to state  [3, 0, 6]
*********************************
|   |   |   |   |   |   |   |   |
| K |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
| K | R |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |
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JAQUE MATE, GANAN LAS  BLANCAS
```

6) The situation generated by confronting a white king and a black king plus a rook each may be considered even. Is it really the case? Justify your answer. In your opinion, what makes this situation of particular interest for the study of adversarial games?

In chess, the situation of having a white king and a black king plus a rook each color, is considered a draw but the situation may not be considered even because you can have more checkmates with the presence of the rook and by studying the situation, you can see all possibilities for not having a draw, and select the best moves to win depending on the depth. An example of this situation can be what we saw in this practical where we had a white king and a black king plus a rook and there was no draw but a win for the whites.

Conclusions

In conclusion, this practical was really interesting for us and at the same time quite time consuming as it required a lot of work to complete. We implemented the minimax, alpha-beta pruning and the expectimax algorithms. We would like to mention that the latter one (expectimax algorithm) isn`t implemented optimally due to time factor hence its execution times are not exactly as optimal as expected, and we see that our algorithms do not make the last movement of corresponding piece which we tried to fix but due to time limitations, we did not manage to solve. However, the algorithms work correctly and can be tested out.