Haskell Parallel Chess Engine

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Introduction

Minimax based chess engine

Bitboards

Parallelization

Live demo

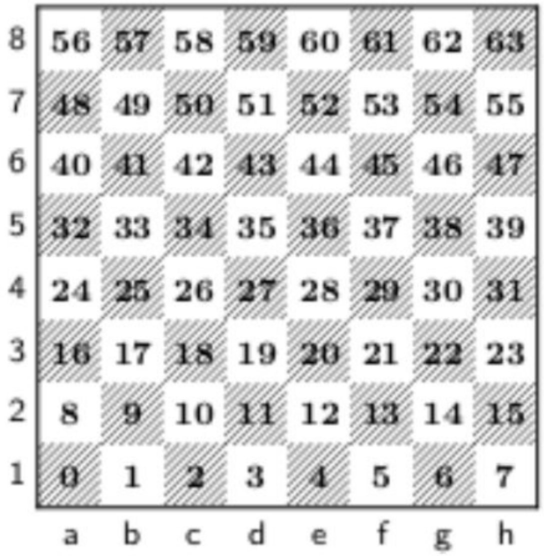
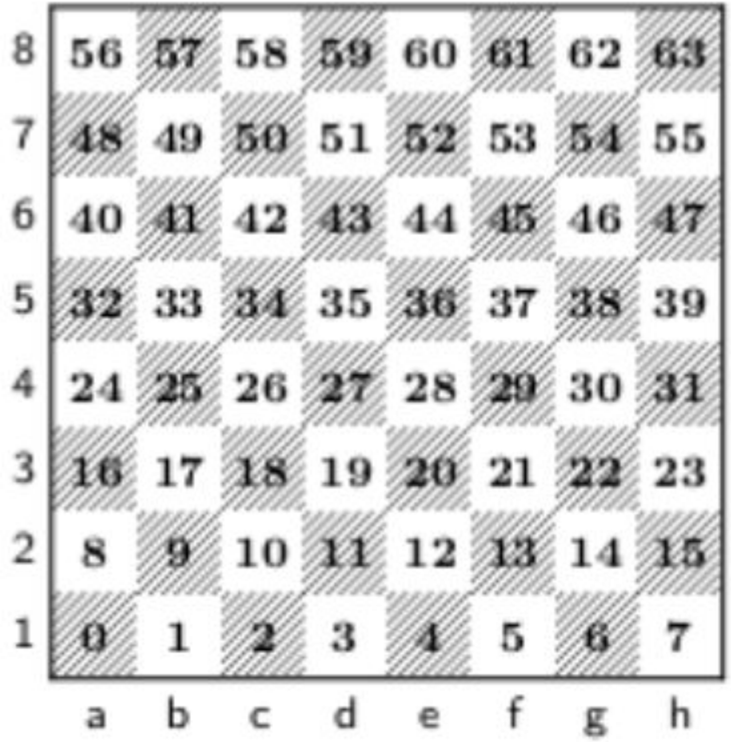


Figure 1: Chess board squares with the corresponding number

Bitboards

- Each square corresponds to a bit in a 64 bit word.
- We can easily map bits to squares
- Each piece can be shown as a 64 bit word



Bitboards

```
startpos :: Board
startpos =
  Board
    { pawnsWhite = 0x000000000000FF00 -- [a,h]2 entire row
    , pawnsBlack = 0x00FF000000000000 -- [a,h]7 entire row
    , knightsWhite = 0x0000000000000042 -- b1 (bit 1) and g1 (bit 6)
    , knightsBlack = 0x4200000000000000 -- b8 (bit 57) and g8 (bit 62)
    , bishopsWhite = 0x0000000000000024 -- c1 (bit 2) and f1 (bit 5)
    , bishopsBlack = 0x2400000000000000 -- c8 (bit 58) and f8 (bit 61)
    , rooksWhite = 0x0000000000000081 -- a1 (bit 0) and h1 (bit 7)
    , rooksBlack = 0x8100000000000000 -- a8 (bit 56) and h8 (bit 63)
    , queensWhite = 0x0000000000000008 -- d1 (bit 3)
    , queensBlack = 0x0800000000000000 -- d8 (bit 59)
    , kingsWhite = 0x0000000000000010 -- e1 (bit 4)
    , kingsBlack = 0x1000000000000000 -- e8 (bit 60)
    }
```

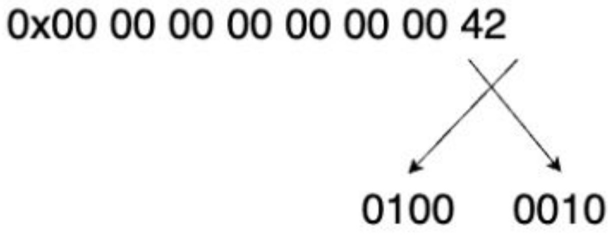


Figure 3: Hex to bitboard mapping

Bitboards

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0

(a) Occupancy (stop before)

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0

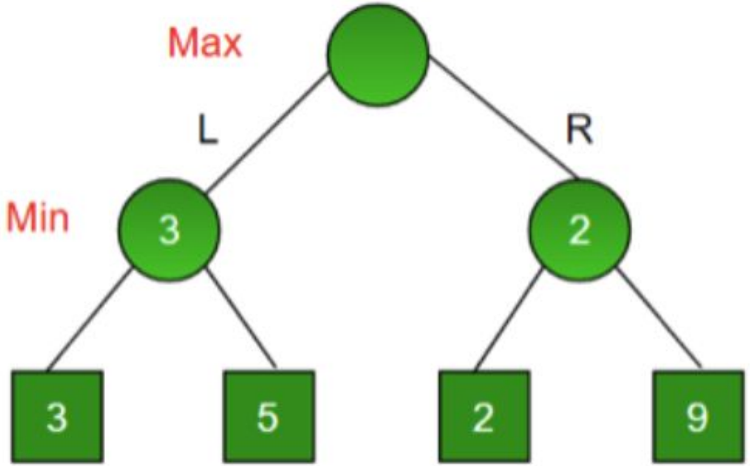
(b) Captureable (stop on)

1	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0
1	0	0	1	0	0	0	0
1	0	0	0	1	0	0	1
1	0	0	0	0	1	0	1
1	1	0	0	0	0	1	1
0	1	1	0	1	1	1	0

(c) Queen moves from a1, h1

Minimax Algorithm with optimizations

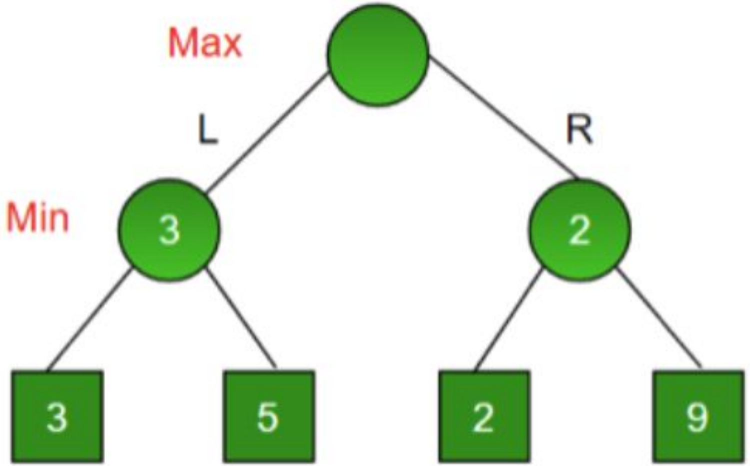
- Each turn the maximizing and min player switch roles and choose the most optimal branch
- Assumes each player plays optimally
- Space complexity 2^n



Minimax Algorithm with optimizations

Caching

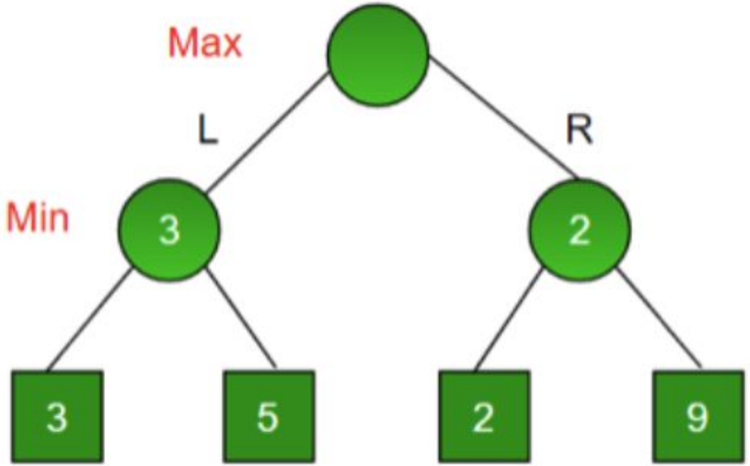
- Avoid recomputing expensive bitboard operations and comparisons
- Significant speedup at higher depths



Minimax Algorithm with optimizations

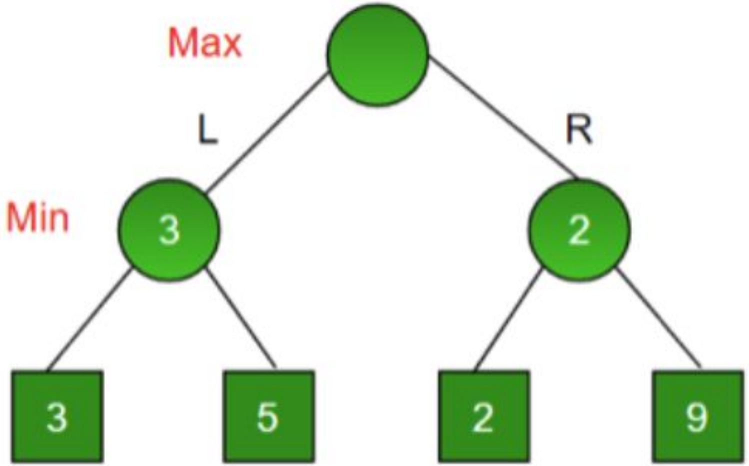
Pruning

- Avoid computing branches that we know the algorithm will never reach to save computational resources
- Has much more overhead than just caching but it takes runtime down even more aggressively

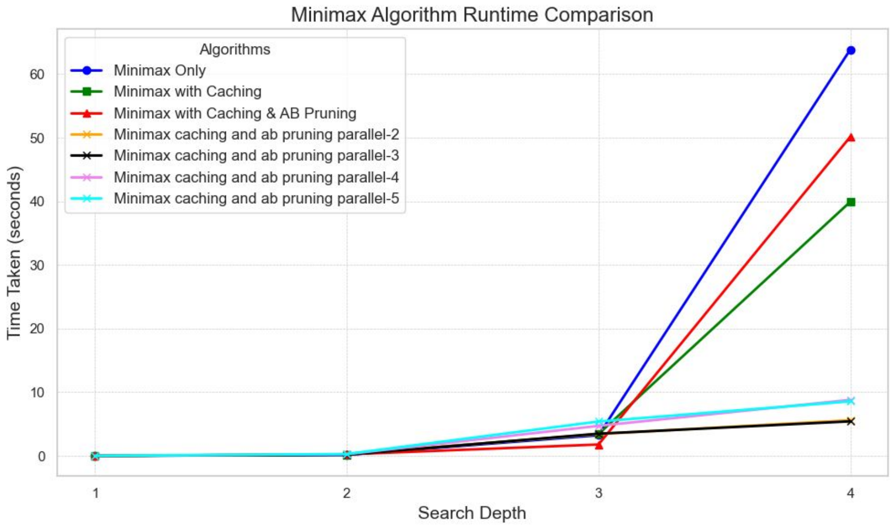


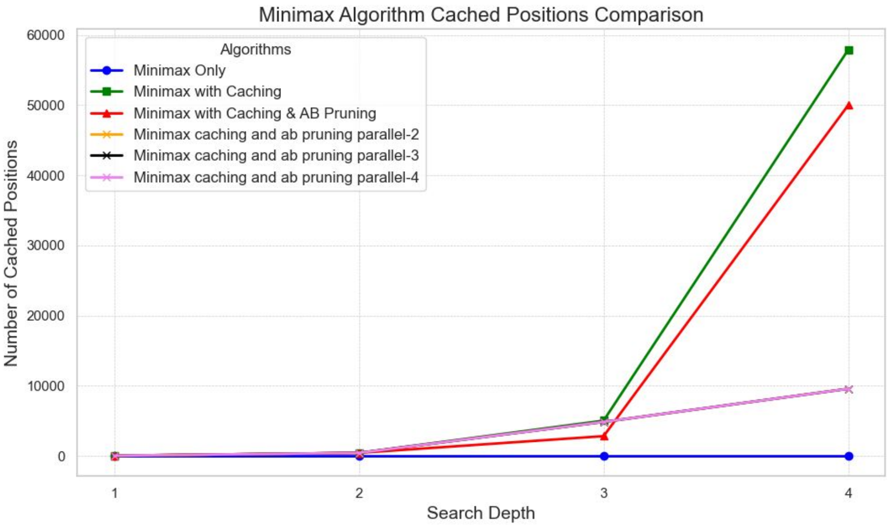
Parallelization

- Parallelize each top level minimax operation
- Leaves enough single threaded work, and breaks down the big work into sizeable chunks to take advantage of overhead
- Danger of exhausting system memory (24gb M3)



Preliminary Results





Preliminary Results - potential issues

- Exhausting resources
- Timing may not be fully accurate