Tic-Tac-Toe Benchmarks

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Abstract

In this report are compared and evaluated all the different implementations of the Minimax algorithm and its variants.

Chapter 1

Intro

The implementation of the different algorithms [1] has been done with a mixture of imperative, object oriented and functional programming to benchmark also these different code styles.

All the algorithms, *Minimax* [2], *Negamax* [3] and *Alpha Beta* [4] with *Transposition Table* [5], are implemented in a naive approach, imperative, and then refined to use *traits* and a more functional approach.

Minimax has been implemented as:

- Raw: imperative.
- Trait raw: using OOD.
- Trait: OOD combined with functional elements.

Negamax has been implemented as:

- Raw
- Trait

Alpha Beta has been implemented as:

- Raw
- Trait
- Raw with transposition table (TT)

Transposition Table has been implemented as:

- simple Hash Table
- Trait

Alpha Beta and Transposition Table are combined to spot differences in the implementation performances.

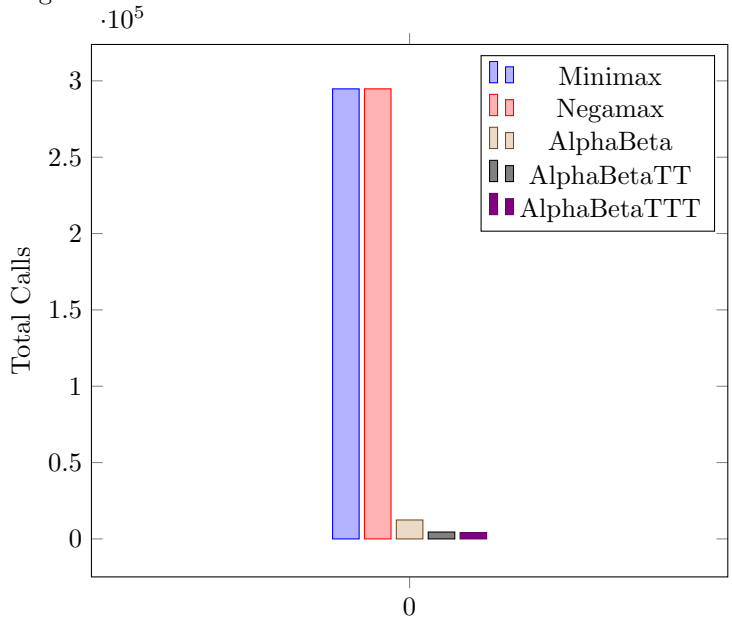
Chapter 2

Results

In this chapter are displayed all the results computed with a Intel I7 CPU.

2.1 Tic Tac Toe

In this section are reported the specific result with the *tic-tac-toe* optimized board game rules.

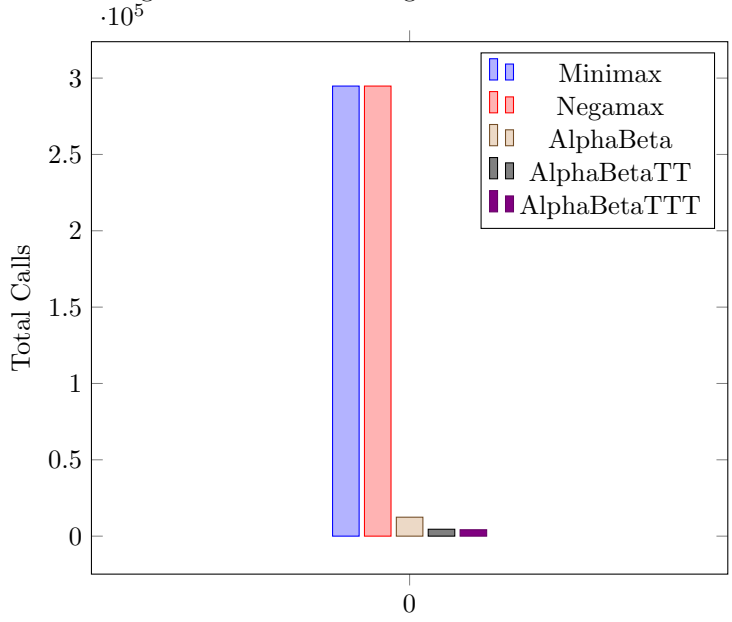


Algorithm	Time (ms)	Total Calls	cache	cache hits
Minimax Raw	650	294778	N/A	N/A
Minimax Trait	655	294778	N/A	N/A
Minimax Trait Raw	808	294778	N/A	N/A
Negamax	308	294778	N/A	N/A
Negamax Trait	596	294778	N/A	N/A
Alpha Beta	75	12413	N/A	N/A
Alpha Beta Trait	91	12413	N/A	N/A
Alpha Beta with TTOld	260	4520	5478	10690
Alpha Beta with TT	211	4520	5478	10690
Alpha Beta with TT Trait	137	4187	1308	3851

Table 2.1: Tic Tac Toe Solver Results

2.2 Board 3x3x3

In this section are reported the specific results with the *board 3x3x3* that are derived from a general *board MxNxK* game rules.



Algorithm	Time (ms)	Total Calls	cache	cache hits
Minimax Raw	259	294778	N/A	N/A
Minimax Trait	366	294778	N/A	N/A
Minimax Trait Raw	350	294778	N/A	N/A
Negamax	161	294778	N/A	N/A
Negamax Trait	316	294778	N/A	N/A
Alpha Beta	46	12413	N/A	N/A
Alpha Beta Trait	68	12413	N/A	N/A
Alpha Beta with TTOld	134	4520	5478	10690
Alpha Beta with TT	82	4520	5478	10690
Alpha Beta with TT Trait	42	4187	1308	3851

Table 2.2: Tic Tac Toe Solver Results

Bibliography

[1] Patrick H. Winston. *Lecture6: MIT Search: Games, Minimax and Alpha-Beta*. MIT OCW. 2010. URL: https://www.youtube.com/watch?v=STjW3eH0Cik.

[2] *Minimax*. Wikipedia. URL: https://en.wikipedia.org/wiki/Minimax.

[3] *Negamax*. Wikipedia. URL: https://en.wikipedia.org/wiki/Negamax.

[4] *Alpha Beta pruning*. Wikipedia. URL: https://en.wikipedia.org/wiki/Alpha%E2%80%93beta_pruning.

[5] *Transposition Table*. Wikipedia. URL: https://en.wikipedia.org/wiki/Transposition_table.