A review of game tree pruning

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2. May, 2019
Overview

1. Introduction
2. Recap
3. Qiescence Search
4. Aspiration Search
5. Principal Variation Search
6. Transposition Tables
7. Conclusion
A review of game tree pruning (1986)
Canadian computer scientist
Co-creator of Principal Variation Search
Creator of computer chess program “Wita”
Participated at computer chess championships
What is pruning?

Methods to decrease number of nodes in a game tree that need to be evaluated

Pruning
Pruning

What is pruning?

Methods to decrease number of nodes in a game tree that need to be evaluated

Alpha-Beta-Pruning:

- function alphabeta(node, depth, \( \alpha, \beta \))
- \( \alpha = \) current best move/ lower bound
- \( \beta = \) upper bound
- Returns evaluation function if depth == 0
In this talk we are going to...
- improve alpha-beta pruning
- discuss more methods and problems

Do the methods still hold up today?
Horizon Effect

Game Tree Pruning

2. May, 2019

7 / 19
Horizon Effect

How can we avoid making moves that are refuted after the maximum search depth?

Solution:

- Increasing search depth for certain moves
- Search until position gets ‘quiet’
Further Enhancements

Performance

How can we prune more branches?

Idea:

- Change $\alpha - \beta$ bounds
- Aspiration Search
Aspiration Search

How to choose the bounds?

- Standard Alpha-Beta: $\alpha = -\infty$, $\beta = \infty$
- Estimate score $V$ of position
- Use material for estimation

<table>
<thead>
<tr>
<th>Piece</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pawn</td>
<td>1</td>
</tr>
<tr>
<td>knight</td>
<td>3</td>
</tr>
<tr>
<td>bishop</td>
<td>3</td>
</tr>
<tr>
<td>rook</td>
<td>5</td>
</tr>
<tr>
<td>queen</td>
<td>9</td>
</tr>
</tbody>
</table>

- Choose error limit $e$
- $\alpha = V - e$, $\beta = V + e$
- Re-search if score is out of bounds
Aspiration Search

How to choose the bounds?

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- Choose error limit $e$
  - $\alpha = V - e$, $\beta = V + e$
- Re-search if score is out of bounds

Does not work well in positions with complex captures
How to improve the search method?

- **Assumption**: moves are ordered from best to worst
  → first move as $\alpha$ bound
- **Search further moves with bounds $\alpha$ and $\alpha + 1$**
  - score $< \alpha$: worse move
  - score $> \beta$: $\beta$ cutoff
  - $\alpha < $ score $< \beta$: re-search branch
Principal Variation Search

Game Tree Pruning

(5, Inf)

(5, 6)

(5, 6)

Jessica Löhr (Universität Heidelberg)
Principal Variation Search

- More branches pruned
- Branches might be re-searched
- Works best if moves are ordered
Move Ordering

Sort moves so that most plausible ones are searched first (often capture moves)

Killer heuristic:

- Saves moves that refute a line
- Two most frequent moves per depth
Move Ordering

Sort moves so that most plausible ones are searched first (often capture moves)

Killer heuristic:
- Saves moves that refute a line
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History heuristic:
- Table of size 64x64
- Frequency for every move is stored
Transposition Tables

Positions might be re-visited
→ Use of tables
Transposition Tables

Positions might be re-visited
→ Use of tables

Can be used to:
- Narrow $\alpha$ - $\beta$ bounds
- Move re-ordering
- Look up score of subtrees
### Possible entry:

<table>
<thead>
<tr>
<th>Entry</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move</td>
<td>Best move in position</td>
</tr>
<tr>
<td>Score</td>
<td>Value of subtree</td>
</tr>
<tr>
<td>Flag</td>
<td>Tree fully searched?</td>
</tr>
<tr>
<td>Height</td>
<td>Depth of subtree upon score is based</td>
</tr>
</tbody>
</table>
Many ways to improve standard alpha-beta-pruning:

- Quiescence Search
- Principal Variation Search
- Use of tables

Methods are still used by modern chess engines!
Stockfish 10: one of today's best chess engines
- Open source
- https://stockfishchess.org/
Thanks for your attention!